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ESSAY

ON THE

NEW METHOD OF BLEACHING:

WITH AN ACCOUNT OF
The Nature, Preparation, and Properties,
OF
OXYGENATED MURIATIC ACID.

TO WHICH IS NOW ADDED,
OBSERVATIONS AND EXPERIMENTS,
On the ART of DYING with MADDER.

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FROM THE FRENCH OF Mr BERTHOLLET.

With Figures of all the Neceſſary Apparatus;
And Explanatory Notes.

By ROBERT KERR, F. R. & A. SS. E.
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Surgeon to the Orphan Hoſpital of
Edinburgh.

SECOND EDITION.

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TO THE HONOURABLE,

THE TRUSTEES FOR FISHERIES,
MANUFACTURES, AND
IMPROVEMENTS,
IN SCOTLAND,

THIS Second Edition of the Eſſay on the New Method of Bleaching, is, with the greateſt veneration for their patriotic and ſucceſsful exertions to encourage and improve the Arts and Induſtry of this Country, moſt reſpectfully inſcribed, by

their moſt obedient,

and very humble ſervant,

EDINBURGH,
SEPT. 1790.

ROBERT KERR.

TRANSLATOR's PREFACE

TO THE

FIRST EDITION.

THE only motive for Tranſlating and Publiſhing the following curious and intereſting Eſſay, is to afford the earlieſt, fulleſt, and moſt authentic information, to the Britiſh manufacturers, upon the newly invented method for expeditious bleaching. The Tranſlator lately received from London a copy of the *Annales de Chymie*, being deſirous to ſee a publication which, from the celebrity of its editors *, promiſed to give very intereſting intelligence of the improvements carrying on in chemiſtry, and the arts connected with that ſcience, which has of late, been cultivated in France with an ardour and ſucceſs beyond example. Whilſt engaged in peruſing the above work, which exceeded his expectations of chemical information, he was ſtruck with the apparent uſefulneſs of Mr Berthollet's Eſſay upon the employment of oxygenated muriatic acid in bleaching, and ſome other analogous arts; and conceiving that the publication of it in Engliſh might tend to the improve-

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* Meſſrs de Morveau, Lavoiſier, Monge, Berthollet, de Fourcroy, le Baron de Dietrich, Haſſenfratz and Adet; all celebrated chemical philoſophers in France.

improvement of the arts and manufactures of Britain, he determined to tranſlate it for that purpoſe.

Thoſe who are moſt concerned in inquiries of this kind, are often prevented, by education, and other circumſtances, from having acceſs to the beſt and earlieſt ſources of information reſpecting new and intereſting diſcoveries. Theſe are too often concealed, from ſelfiſh views, under the veil of myſtery, and boaſted of, by men acquainted with them, under pretence of being their own inventions.

Such has, in a conſiderable degree, been the caſe with the proceſs for bleaching, which is fully explained in the following pages. Though, in reality,

lity, diſcovered by Mr Berthollet, a celebrated chemical philoſopher at Paris, ſeveral perſons in France, and ſome in England, have endeavoured to avail themſelves of the diſcovery, by ſpreading falſe ideas of the proceſs; and, in the latter country, have even aſſumed the merit of inventors, to ſecure profit to themſelves, under the ſanction of excluſive privileges, ſurreptitiouſly obtained.

In the following Eſſay, Mr Berthollet has fully explained every circumſtance relative to the preparation, and application to uſe, of the new chemical liquid for bleaching, which he is well enabled to do from his own extenſive experiments, and from the information of ſeveral philoſophical friends. He has, beſides, pointed out all the precautions, and aſſiſtant operations, neceſſary for enſuring ſucceſs, and for avoiding ſuch hurtful effects upon the ſubſtances intended to be bleached, as have unfortunately, in ſeveral inſtances, owing to unſkilful management, raiſed great objections to the new proceſs. To theſe he has added ſeveral uſeful hints, by which the proceſs, in the hands of ingenious artiſts, may be greatly improved in efficacy, cheapneſs, and conveniency of application.

The verſion of Mr Berthollet's Eſſay, which is here preſented to the Public, is as cloſe and literal as the different idioms of the two languages would permit; it being the Tranſlator's earneſt wiſh to render uſeful and intelligible,

gible, to his readers, a work which promiſes to be of infinite conſequence to manufacturers.

The only freedom which is taken, in this publication, with Mr Berthollet's work, is by dividing it into ſections, for more ready conſultation and reference. A ſupplementary ſection is likewiſe added, containing ſome farther obſervations upon the uſe of oxygenated muriatic acid, extracted partly from another Memoir of the ſame author, and partly from one by Mr Chaptal, an ingenious chemiſt of Rouen.

It is probable, that the chemical language employed in this Eſſay will be objected to, eſpecially by the numerous and reſpectable adherents of the old chemical philoſophy. But, without pretending to enter into the controverſy reſpecting the comparative merits of the ancient and modern chemical theories and nomenclatures, the Tranſlator conceives, that he had no right to make Mr Berthollet ſpeak a language, which, upon the moſt mature deliberation, he has choſen to abandon. Beſides, as that highly uſeful ſet of men, for whoſe convenience this tranſlation is chiefly deſigned, muſt be ſuppoſed equally unacquainted with both nomenclatures, he hopes there can be no impropriety in endeavouring to give them a knowledge of Mr Berthollet's important diſcovery, in the philoſophical language of its ingenious author. Scientific terms muſt have been employed in either caſe, accompanied with explanatory notes, to render them intelligible to thoſe unacquainted with the ſcience; and, had terms been uſed, dependant upon a theory the Tranſlator does not approve, beſides the aukwardneſs of conſtraint, he muſt have been forcibly drawn into diſagreeable and unavailing controverſy.

To explain the technical language, and to illuſtrate the chemical objects which occur in the courſe of this Eſſay, a conſiderable number of explanatory notes are added, which, it is hoped, will be found uſeful. Indeed, to the Tranſlator, they ſeemed neceſſary; becauſe Mr Berthollet's Memoir, being contained in a publication chiefly, if not entirely, addreſſed to the philoſophical

phical world, is not couched in that familiar language which is adapted for the manufacturer. Many of theſe are men of good education, and of ſound and comprehenſive minds; but, in the peruſal of the following work, it will appear, that the author means it to be of uſe, even to the lower orders of weavers and threadmakers; that they may be enabled to enjoy the full fruits of their honeſt induſtry.

Such were the views and intentions of the Tranſlator, in the deſign and conduct of the work now preſented to the public; and his utmoſt wiſh will be fully gratified, if it is ultimately found to advance any of the purpoſes which it ſeems calculated for promoting. His expectations of uſefulneſs, at firſt ſanguine, were, however, ſomewhat damped, by intelligence from a friend, that the oxygenated muriatic acid had been tried in this country, and abandoned, as not anſwering the purpoſes expected from it. As the information was by no means explicit, either with regard to the methods of employing the preparation, or the cauſes of its failure, he was led to believe, that the dereliction might have proceeded from ſome of the accidents which are mentioned in this Eſſay, the cauſes of which are there explained, and their continuance guarded againſt, by proper cautions and inſtructions. For theſe reaſons, he determined to proceed; and had reſolved to requeſt permiſſion, from the Honourable Truſtees for Fiſheries, Manufactures, and

Improvements, to uſher this little work to the notice of the world under their patronage and protection.

His hopes and intentions have ſince been greatly ſtrengthened, by obſerving, that the Truſtees have offered a premium for the moſt ſucceſsful application of the new method of bleaching to practice. Their information upon the various ſubjects of manufacture, and the arts connected with theſe, muſt neceſſarily be extenſive and particular; and he thence concludes, that his ſuſpicions, with regard to any failures of ſucceſs, in the trials of the oxygenated muriatic acid, have been well founded; and that the want of ſucceſs, in theſe trials, proceeded more from ſome error in the conduct of the proceſs, than from the nature of the ſubſtance employed. The above circumſtance gives him the additional ſatisfaction of thinking, that, in the ſteps he had taken, before the appearance of the above advertiſement, he had been employing his leiſure for the advancement of the arts, in a manner conſiderably correſponding with the enlarged and patriotic views of the Honourable Truſtees. He has now the high ſatisfaction of being honoured with their approbation of his well meant endeavours, by condeſcending to accept the offered dedication of this Eſſay.

In the progreſs of tranſlating, ſeveral points of uſeful inveſtigation have occurred, which, if properly proſecuted, ſeem to promiſe very advantageous improvements upon the new method of bleaching. But, as it is extremely uncertain how far the neceſſary avocations of a laborious profeſſion may leave time ſufficient for carrying on the requiſite ſeries of experiments, it may not be amiſs to point out, in general, what ſeems to be the beſt method of proceeding, in order to diſcover how the new bleaching proceſs may be carried to its utmoſt perfection. Others, who have more leiſure, or greater knowledge of chemiſtry, may perhaps be induced to beſtow their time and talents to the advancement of this uſeful art.

By means of one or other of the teſts mentioned by Mr Berthollet, and by an extenſion of the hint he gives for employing them, to conſtruct an eaſily applicable inſtrument, which may be termed a *muriometer*, for determining, with accuracy, the comparative degrees of ſtrength of the oxygenated liquor, from that of the ſtrongeſt concentration, to the weakeſt dilution in which it is capable of acting, with any uſeful efficacy, upon coloured ſubſtances. In the next place to determine, by a ſeries of accurate experiments, the utmoſt degrees of ſtrength of the oxygenated liquor, as meaſured by the above muriometer, which can ſafely be uſed for whitening various ſubſtances; and the weakeſt ſtates of the liquor that are capable of producing any uſeful effect upon theſe ſubſtances; ſuch as linen and cotton cloths and threads, of various degrees of fineneſs.

A ſimilar ſet of experiments ſhould be made with cauſtic alkaline ley, ſo as to reduce its ſtrengths to a practical ſcale; and to aſcertain the degrees of ſtrength, according to that ſcale, which are ſafely and uſefully applicable to the various kinds of goods. And, laſtly, a ſtandard for determining the ſtrength, in different degrees of dilution of the ſulphuric acid, and the proper application of theſe degrees, in a regular manner, to each ſpecies of goods, ought to be conſtructed upon ſimilar principles with thoſe adapted for the oxygenated liquor and alkaline ley.

Such are the ideas which at preſent offer themſelves, as beſt calculated for conducting a ſet of chemical experiments, by which the proceſs of bleaching may be ſtill farther improved; and, though others are thus invited to aſſiſt in advancing this apparently important purpoſe, the Tranſlator by no means intends to abandon his views of the ſubject, ſhould more direct engagements allow the neceſſary leiſure. And whatever farther information may occur, either from his own experiments, or thoſe of others who may favour him with their communications upon the ſubject, he ſhall take the earlieſt opportunity of giving it to the public.

Being exceedingly deſirous of contributing, by every means in his power, to advance the intereſt of manufacture, the Tranſlator takes this opportunity to offer his aſſiſtance or advice to any perſon who may incline to make trial of the new proceſs, either in the way of experiment, with a view to improvement, or in the application of it to uſe, in the large way of manufacture.

Since the work was printed off, the Tranſlator has learned, from a Memoir by Mr de Fourcroy, in the firſt volume of the *Annales de Chymie*, that Azote, or the baſis of azotic gas, is often found combined with native black oxyd of mangaueſe. The note in page 43 *, upon that ſubject, is therefore, in ſome degree, erroneous. So far as relates to a large impregnation of calcareous matter in the manganeſe, there is no neceſſity of altering what is there ſaid [*]; but it may be neceſſary to remark, that, when manganeſe is found, upon trial, to contain much azote, it can be eaſily freed from it, by expoſure to a temperature ſomewhat ſhort of the red heat, for ſome time before it is employed in the oxygenating proceſs. This lower degree of heat ſeparates the azotic gas without affecting the oxygen; which latter can only be driven off by heat accompanied with light, or what is called a *red heat*.

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* This refers to a note in the firſt edition, which is altered in the preſent impreſſion.

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[*] The note on that ſubject will be found in another part of the work.

POSTSCRIPT

TO THE

SECOND EDITION.

THE rapid ſale of the firſt edition of this work, the whole impreſſion having ſold off in four months, gives full proof of the public approbation of the performance, and encourages the Tranſlator to hazard a ſecond edition. He has availed himſelf of every opportunity of improvement, by the correction of ſome inadvertencies, and by additional notes, in elucidation of ſuch paſſages as ſeemed to require it.

Already, in conſequence of the invitation in the preface, he has been applied to, by an eminent Manufacturer, to aſſiſt and adviſe in the erection of the neceſſary apparatus for giving a full trial to the New Bleaching proceſs; and hopes to have it in his power, in the courſe of the enſuing winter, to give an account of the reſults of the experiments which are to be inſtituted, as ſoon as the apparatus can be got ready.

To this edition are added, from the ſame author, a ſeries of obſervations and experiments, intended to improve the Art of Dying with Madder, which ſeem, ſo far as he is able to judge, highly intereſting to Calico Printers; a buſineſs now of very conſiderable importance, in the preſent improving ſtate of Britiſh manufactures; the advancement of which, in any degree, the Tranſlator would conſider as his higheſt honour, and a ſufficient recompenſe for any little labour he may beſtow on the ſubject.

Great pains have been taken to render this edition as perfect, as accurate, and as intelligible, as poſſible; though, indeed, ſo much attention was paid to the firſt, as to leave very little to do in that reſpect. Should any future edition be called for, the only object which remains, is to give ſuch additional information as may be furniſhed by experiment; and this, it is hoped, will ſoon be accompliſhed.

Although, in the notes, every opportunity is taken of explaining ſcientific terms, more eſpecially thoſe of the new chemical nomenclature, it may, perhaps, be uſeful to ſubjoin a liſt of the chemical terms employed, and their explanation, in language as familiar as poſſible.

Caloric—Otherwiſe called the matter of fire and of heat, is the ſuppoſed elementary cauſe of heat and of light, and of evaporation.

Gas—Signifies any ſubſtance which reſembles air or vapour, in its ſtate of exiſtence.

Oxygen—Is the ſolid baſis of pure or vital air, which is ſuppoſed to conſiſt of oxygen, combined with the matter of fire or caloric.

Oxygen gas—Formerly called pure, vital, dephlogiſticated, or empyreal, air, is that part of the atmoſphere, about one third of its bulk, which alone is capable of ſupporting animal life, by means of reſpiration, and which alone can feed flame or combuſtion.

Azote—The ſuppoſed ſolid baſis of azotic gas; which, by the modern theory, conſiſts of azote combined with caloric.

Azotic gas—Called, formerly, phlogiſticated air, or atmoſpheric mephitis, forms the larger part, nearly two thirds, of our atmoſphere, and is, by itſelf, inſtantaneouſly deſtructive of animal life when received into the lungs, and incapable of ſupporting flame.

Aqueous gas—Steam, or water in the ſtate of inviſible vapour, to which it is changed by combination with caloric.

Carbonic acid gas—Otherwiſe fixed, or fixible air, or chalky acid air.

Carbonic acid liquor—Is the above gas combined with water.

Muriatic acid—Formerly ſpirit of ſea ſalt, or marine acid.

Muriatic acid gas—The muriatic acid deprived of the neceſſary quantity of water for giving it fixity, and combined with caloric, in form of air.

Muriatic acid liquor—The muriatic acid gas combined with water: When to complete ſaturation, it is called concentrated; and, when the water is in exceſs, it is ſaid to be diluted.

Oxygenated muriatic acid—The muriatic acid combined with a large proportion of oxygen, by which it acquires new properties, which are particularly treated of in the following work.

Oxygenated muriatic acid gas—Is the oxygenated muriatic acid, deprived of the water neceſſary to its fixity, and combined with caloric.

Oxygenated muriatic acid liquor—or, more ſhortly, *oxygenated liquor*, is the oxygenated muriatic acid gas combined with water; and this, like the muriatic acid liquor, is diſtinguiſhable into concentrated and dilute, according to the proportions of water.

Sulphuric acid—Formerly oil of vitriol, or vitriolic acid; likewiſe diſtinguiſhed, by its quantity of water, into dilute and concentrated.

Sulphurous acid—Formerly phlogiſticated vitriolic acid.

Sulphurous acid gas—The above acid deprived of water, and combined with caloric.

Sulphurous acid liquor—This gas united to a ſufficient quantity of water, to prevent its aſſuming the form of gas.

Nitric acid—The acid of nitre, ſpirit of nitre, or aqua fortis.

Nitrous acid—Formerly phlogiſticated nitrous acid.

Potaſh—The fixed vegetable alkali.

Soda—The fixed mineral alkali, barilla, or ſalt extracted from kelp aſhes.

Carbonats of potaſh and of ſoda—Are what are called mild fixed alkalies, being the two above mentioned alkaline ſalts combined with carbonic acid. When deprived of that acid, by means of quicklime, they are called cauſtic alkalies.

Alkaline liquor—Any of theſe ſalts diſſoved in water.

Cauſtic alkaline liquor, or ley, or lixivium—Either of theſe alkalies deprived of carbonic acid by quicklime, and diſſolved in water. Diſtinguiſhable, according to the proportions of water, into concentrated and dilute.

Oxygenated alkaline liquor—The ſolution in water of either of theſe alkalies, impregnated with oxygenated muriatic acid gas, in the way to be hereafter deſcribed.

Calcareous ſpar, calcareous matter, calcareous

careous earth—Lime-ſtone, chalk, marble, or other ſubſtances capable of being burned into lime.

Oxyd—Formerly, but improperly, called calx, is a general term uſed to ſignify the ſtate of a metal, whether natural or artificial, which is produced by combination with oxygen.

Oxyd of mangane ſe—Calx of mangane ſe, a peculiar ſemi-metal, the uſe of which, in bleaching, is treated of in the following Eſſay.

Black oxyd of mangane ſe—A black native oxyd, or calciform ore of mangane ſe, plentiful in moſt mines of iron ore.

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ESSAY

ESSAY

ON THE

NEW METHOD OF BLEACHING.

SECT. I.

General Account of the Preparation, Nature, and Properties, of Oxygenated Muriatic acid *.

FOR the original diſcovery of the oxygenated muriatic acid, the world is indebted to the celebrated

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* This acid is called the *dephlogiſticated muriatic acid* by Scheele, Bergman, and other celebrated

Scheele of Sweden; and to him is likewiſe owing the knowledge we poſſeſs of its effects upon the colouring matter of vegetables. In his valuable eſſay upon the preparation, nature, and properties, of this curious and intereſting ſubſtance, publiſhed alongſt with his other

eſſays

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celebrated chemiſts, of the old or phlogiſtic ſchool. I have, however, in this Eſſay, adopted the new language of the French chemical philoſophers, both becauſe it is employed by the ingenious author Mr Berthollet, and becauſe, in my opinion, it is better adapted for uſe than the language of the old chemical nomenclature: Strictly ſpeaking, however, as all acids conſiſt of oxygenated baſes, this ſhould be called *ſuper-oxygenated muriatic acid;* but the term uſed by the French chemiſts being appropriate, will anſwer the chief purpoſe of nomenclature, perſpicuity, perfectly well, and is therefore retained.—T.

eſſays upon chemical ſubjects, we find the following account of it, which I here tranſcribe as a proper introduction to this Eſſay.

'The properties of oxygenated muriatic acid, are beſt diſcoverable when in the ſtate of gas, or, as it is called, the *elaſtic aëriform ſtate* *. When it

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* It may be neceſſary to ſuch readers as have not had occaſion to ſtudy chemiſtry, to give the following explanation of terms. Muriatic acid is the acid prepared from ſea ſalt, commonly called *ſpirit of ſalt*. By a proceſs, which will be deſcribed in this Eſſay, it is made to combine with a large portion of the baſe of pure or vital air, named *oxygen*; and in this ſtate it gets the name of *oxygenated muriatic acid*. This acid is very difficultly made to combine with water, being very prone to retain

‘ is to be prepared, let a quantity of powdered manganeſe * and common muriatic acid be put into a glaſs retort, having a receiver capable of holding about twelve ounces, but on-

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retain the ſtate of gas, or to reſemble air. This gas, which is of a yellow colour, was formerly called *muriatic air*, or *dephlogiſticated muriatic air*, now more properly, by the French, *oxygenated muriatic acid gas*. When combined with water, as ſhall be afterwards ſhown, it becomes *oxygenated muriatic acid liquor*.—T.

* Manganeſe, or rather native black oxyd, or calx of manganeſe, is a black, heavy, earthy looking, calciform ore of a ſemimetal which bears the ſame name. Its chief uſe, till the above diſcovery of Scheele, was for depriving flint glaſs of the green colour it is ſo liable to, on account of a portion of iron contained in the materials for making glaſs.—T.

'ly containing two drams of water,
'luted to its beak by means of grey
'paper. The retort is to be placed in
'a ſand bath, in ſuch a poſition that
'any unchanged acid, which may riſe
'and condenſe in its neck, ſhall fall
'back again upon the mangaueſe.
'Heat being gradually applied, in a-
'bout a quarter of an hour the recei-
'ver becomes filled with yellow va-
'pours of the oxygenated muriatic
'acid gas.

'The firſt receiver is now to be re-
'moved from the retort, and another
'applied in the ſame manner, as is be-
'fore directed. If the paper luting
'has been properly put on, the air
'ruſhes out with ſome force when the
'juncture is opened. The receiver fil-

'led with gas muſt be carefully ſtopped, and ſet by in a cool place for uſe.

'In this manner, ſeveral ſucceſſive receivers or bottles may be filled with oxygenated muriatic acid gas; the ſmall quantity of water directed to be put into each, ſerving to condenſe any vapours of common muriatic acid which may paſs over during the proceſs. I make uſe of ſeveral receivers, that I may not be obliged to repeat the proceſs for preparing this gas for each experiment in which it is required; and I prefer ſmall ones, becauſe every time they are opened, a conſiderable portion of the gas is neceſſarily diſſipated into the ſurrounding air. The ſubſtances ſubmitted to ex-

'periment, for diſcovering the action 'of this oxygenated muriatic gas *, are 'ſuſpended in the necks of the bottles 'into which it is received during the 'above deſcribed proceſs.

'The corks with which the receivers 'are ſtopped become yellow, in the 'ſame manner as happens from the 'action of nitrous acid vapours.—Pa-'per dyed blue with infuſion of turn-'ſole † becomes almoſt white.—All the 'red,

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* The terms uſed in this extract are altered from the old chemical language, uſed by Scheele, to that of the new nomenclature, for the ſake of uniformity.—T.

† Turnſole, or heliotropium, is a ſubſtance much uſed for aſcertaining the preſence of diſ-engaged

'red, blue, or yellow flowers, and even 'the green parts of vegetables, are in 'a very ſhort time rendered pale and 'colourleſs.—In conſequence of theſe 'experiments, the liquor in the recei'vers becomes changed into weak com'mon muriatic acid *.—Neither acids 'nor

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engaged acid in chemical experiments. It gives a blue colour, which changes to red by the action of all the commonly known acids.—T.

* This change of the acid, from its oxygenated to its common ſtate, happens in conſequence of the oxygen or baſis of vital air, which it had obtained from the manganeſe, being taken from it again; becauſe the ſuperabundant oxygen which the acid had received from the manganeſe, and to which its peculiar properties in the oxygenated ſtate are owing, poſſeſſes a ſtronger attraction for the ſubſtances ſubmitted

'nor alkalies are able to reſtore the 'colours of flowers and plants thus al'tered or deſtroyed.'

I have repeated theſe experiments, and have exerted my endeavours to throw additional light upon the nature, and principal properties, of the oxygenated muriatic acid. I have ſhown, that one portion of the common muriatic acid employed in the preparation diſſolves the oxyd * of manganeſe, and diſplaces

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ſubmitted to experiment than it has for the muriatic acid.—T.

* The term *oxyd* here employed is adopted by the French chemiſts for denominating metals in that ſtate to which former chemiſts gave the name of *calx*; and certainly the new term

diſplaces a part of the oxygen, or baſis of vital air, which was, in that ſubſtance, combined with the metal in lar-

ger

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is more proper, and more expreſſive, than the old one. The word *calx* ſignifies lime, to which ſubſtance the metals, as altered by the joint operation of heat and air, have no reſemblance. The alteration they ſuffer is cauſed by a large quantity of oxygen, or the baſis of vital air, entering into combination with them, ſo as to give them new properties. The change itſelf is very properly denominated *oxydation*, or combination with oxygen; and the metal ſo changed is called an *oxyd.* The black ore of manganeſe, employed for converting muriatic acid into the ſtate firſt diſcovered by Scheele, and treated of in this Eſſay, is a native oxyd of manganeſe, containing a very large proportion of oxygen combined with it; or, as the phlogiſtic chemiſts ſay, it is a very highly calcined and dephlogiſticated calx of manganeſe.—T.

ger proportion than is neceſſary for enabling it to be diſſolved in acids. This ſuperabundant and now diſengaged oxygen being in a non-elaſtic form, or, as Prieſtley calls it, in a naſcent ſtate, and being thereby greatly diſpoſed to enter into new combination, unites itſelf to the other portion of the muriatic acid, and, in conſequence of this union, the oxygenated muriatic acid gas is produced.

I have explained this theory, reſpecting the compoſition of the oxygenated acid, at conſiderable length in ſeveral Memoirs, which are printed in the collections of the Academy of Sciences for 1785, and the following years, and in the Journal de Phyſique for June 1785 and Auguſt 1786, to which I muſt refer for particulars. But, that ſuch as have not applied themſelves to the ſtudy of chemiſtry may be enabled, not only to perform the proceſs which I mean to deſcribe, but to vary and modify and improve it, I ſhall here relate ſome of the experiments which are given in detail in the Memoirs above referred to. In ſo doing, I ſhall omit the more generally extended chemical view of the ſubject there taken, and ſhall here confine myſelf to the compoſition of the oxygenated acid, and the action which it exerts upon colouring or coloured ſubſtances.

According to Scheele, in the Eſſay I have already quoted, 'the muriatic 'acid, being deprived of phlogiſton, 'which is one of its component ingre-

‘ dients in its ordinary ſtate, will only ‘ unite in a very ſmall proportion with ‘ water, which thereby does not acquire ‘ very ſtrong acid properties.’

I ſuſpect that he only examined the water which had been barely in contact with the gas during the proceſs, and concluded from thence that the gas was very ſparingly ſoluble in water. From this circumſtance, he judged it to be better, and more convenient, to employ the gas itſelf in his experiments, than the weakly impregnated water. Beſides, this water neceſſarily contains ſome common unchanged muriatic acid, which paſſes over during the proceſs into the receiver, if care be not taken to condenſe and retain it in an intermediate bottle placed between the retort and receiver, as will be particularly pointed out in the ſequel; which precaution does not appear to have occurred to Scheele.

My firſt object, in the experiments I have related in the Memoirs above referred to, was to examine the ſolubility of the oxygenated muriatic acid gas in water; ſuppoſing that, if I could procure a ſomewhat concentrated ſolution, it would be more conveniently applicable to experiments than when in the ſtate of gas. I ſoon diſcovered that this gas is more readily, and in larger quantity, ſoluble in water than carbonic acid gas * or fixed air; and that water

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* What has long been called *fixed*, or *fixible air*, being really an acid in the ſtate of gas, has

water ſaturated with it acquires a very penetrating odour, becomes of a yellowiſh colour, and is poſſeſſed of ſome very ſtriking properties. Theſe firſt attempts

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has of late received ſeveral new denominations. It has been called *aërial acid*, as exiſting very readily in the ſtate of an air, or more properly of gas, and plentifully in the atmoſphere. The *chalky acid*, as procurable in large quantities from chalk, and other mild calcareous ſubſtances. The name given to it in this Eſſay is derived from the knowledge of its compoſition, as lately aſcertained by the French chemiſts to conſiſt of the elementary part of charcoal, named *carbone*, or *char*, united with oxygen, or the acidifying principle. Hence it is called, with ſtrict propriety, *carbonic acid* in general; *carbonic acid gas* when in the aërial form; and *carbonic acid liquor* when combined with, or diſſolved in water.—T.

attempts were made by agitating water in contact with the gas, in the ſame manner as is done in the common proceſs for impregnating water with carbonic acid gas; but, owing to the ſuffocating vapour which exhales from the water in this manner of operating, I was ſoon obliged to ſubſtitute the diſtilling apparatus contrived by Mr Woulfe in place of the more common means of impregnating water with the ſoluble gaſſes.

I placed, between the retort and the bottles filled with water, which, in that apparatus, is intended for being impregnated with gas, a ſmall bottle containing water, and ſurrounded with ice, on purpoſe to condenſe ſuch vapours of common muriatic acid as might happen to diſtil over without being oxygenated; and I, in the ſame manner, ſurrounded the bottles of water in the apparatus with ice, for promoting the ſolution or condenſation of the oxygenated gas. When I performed the proceſs carefully in this manner, I obſerved, that, when the water became ſaturated, part of the gas aſſumed a concrete form *, and precipitated ſlowly to the bottom of the water.

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* From this circumſtance, it appears, that although oxygenated muriatic acid be greatly diſpoſed to aſſume the form of gas in the ordinary temperature of the atmoſphere, it is, in reality, capable of cryſtalizing into a ſolid ſtate in low temperatures. Hence, by proper precautions, it might be very greatly concentrated; but then, from its ſmall ſolubility in

If ſome water, impregnated as above with oxygenated muriatic acid, be put into a bottle, from the mouth of which a tube, properly bent, is introduced below a receiver, in a pneumato-chemical * apparatus, filled with, and inverted

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water, and great volatility, this property will be of little uſe; and the manner of uſing it recommended in the following pages will be found vaſtly more convenient.—T.

[*] The pneumato-chemical apparatus is a trough or baſon filled with water or quickſilver, and containing jars or receivers filled with one of theſe fluids, and inverted into the trough. Its purpoſe is for receiving, and retaining for examination, ſuch airs or gaſſes as are procured by different means from various bodies. A particular account of the apparatus, and the manner of uſing it, will be found in Lavoiſier's Elements of Chemiſtry.—T.

verted in water; and, if the acid liquor in the bottle or flaſk be in this ſituation expoſed to the direct influence of the ſun's light, in a very ſhort time ſmall globules of air will be diſengaged from the oxygenated muriatic acid liquor. Theſe, paſſing through the bent tube, will riſe in the receiver, from which the water will be diſplaced; and, when the gas or air procured in this manner is examined, it is found to conſiſt of very pure oxygen gas, or what is commonly called *pure vital air*. When theſe globules of air ceaſe to be diſengaged, the liquor is found to have loſt its peculiar odour; it is become colourleſs, and all the diſtinguiſhing properties of oxygenated muriatic acid no longer remain; it is changed from oxygenated muriatic acid liquor, or water impregnated with oxygenated muriatic acid, into dilute muriatic acid, or ſpirit of ſalt, or water weakly impregnated with ordinary muriatic acid.

This ſimple experiment ſufficiently proves, and in the moſt deciſive manner, that oxygenated muriatic acid is in reality a combination of common muriatic acid with oxygen, or the baſis of vital air. Indeed, oxygen is ſo abundantly contained in the black oxyd of manganeſe, that nothing more is neceſſary for procuring it in large quantity, in the diſengaged aëriform ſtate, than to expoſe the manganeſe in proper veſſels to the action of a ſtrong fire *.

After

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* By expoſure to heat in this manner, the black oxyd of manganeſe is changed to a grey or

After this has been done, the manganeſe is no longer fit for the preparation of oxygenated muriatic acid, being deprived of that ſuperabundant proportion of oxygen which is neceſſary for converting a part of the muriatic acid employed into its oxygenated ſtate.

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or white colour, in conſequence of the above mentioned loſs of part of its oxygen. It is then changed to an oxyd or calx, in that ſtate or degree of oxydation which is beſt fitted for being diſſolved in acids, which it then readily does without efferveſcence, and without altering the nature of the acids in any degree. If, in this leſs oxydated ſtate, it be expoſed for a conſiderable time to the action of the air, it recovers its ſuperabundant oxygen, which it gradually attracts from the atmoſphere, and thereby regains its black colour, and its fitneſs for oxygenating the muriatic and other acids.—T.

It is worthy of remark, that light has the power which is not poſſeſſed by heat alone, to diſengage and reſtore to its aëriform ſtate the oxygen which was combined with the muriatic acid, in ſome degree deprived of its elaſtic form. In this proceſs, it appears that light enters into combination with the oxygen, and that to this union the elaſtic form of vital air, or oxygen gas, is owing *; which, in loſing its elaſtic aëriform

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* This ſhort account of the combination and diſengagement of light, and production of heat, refers to the new doctrines which have lately been eſtabliſhed upon the foundation of Dr Black's great diſcovery of latent and ſenſible heat. From that elegant theory, which rationally accounts for the production of aëriform ſubſtances, by the combination of heat in

aëriform ſtate, during rapid combuſtion with certain ſubſtances, again allows the principle of light to eſcape, whilſt, at the ſame time, a large quantity of

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in a latent ſtate with ſolid bodies, and the production of ſenſible heat and light, during the paſſage of aëriform ſubſtances to the ſolid ſtate, by means of the evolution of the latent heat, to which their aëriform ſtate was owing; and from attending to the abſorption and fixation of vital air during combuſtion, and other analogous proceſſes, a new theory of chemiſtry has been brought forward, attended with very ſtrong proofs, which entirely ſet aſide the neceſſity of a hypothetical phlogiſton in accounting for chemical phenomena. The reader, who may be curious to inquire into this ſubject, will find it fully diſcuſſed in Lavoiſier's Elements of Chemiſtry, and in the text and notes of the ſecond edition of Kirwan's Eſſay upon phlogiſton.—T.

ſenſible heat is produced. It muſt be confeſſed, however, that we are hitherto entirely ignorant of the relation which ſubſiſts between heat and light.

When vegetable colours are immerſed in oxygenated muriatic acid liquor, they are deſtroyed more or leſs completely, and quicker or ſlower, according to circumſtances. A mixture of different colours, in a ſimilar expoſure, ſuffers the ſame change; only, that ſome are deſtroyed more readily than others, and that thoſe only which reſiſt moſt remain longeſt; whilſt even theſe are leſs or more altered at the ſame time, according to their natures, when conſidered relative to the action of the oxygenated acid. In general, the yellow colours reſiſt its action longeſt, but all are, at laſt, entirely deſtroyed.

When the oxygenated acid has entirely ſpent its power of acting upon the vegetable colours, it is found reduced to the ſtate of ordinary muriatic acid. Hence we may fairly conclude, that the colouring vegetable matters, which have been acted upon and deprived of their properties of producing colour, have taken away the oxygen from the acid by a ſtronger chemical attraction, and have, by means of this combination, acquired new properties, whilſt they have loſt that of producing colour.

I ſhall not at preſent inquire into the properties which theſe oxygenated particles have acquired; it is ſufficient for the preſent purpoſe to obſerve, that the above fact fully proves, that the oxygenated muriatic acid owes its property of deſtroying colours to the oxygen which it acquired from the mangane ſe during the proceſs in which it is prepared. It likewiſe appears evident that the oxygen, which is very abundantly contained in oxygenated muriatic acid, is very ſlightly attached to the common muriatic acid of the compound, and very readily quits that connection to form new combinations with ſuch other ſubſtances as poſſeſs affinity or attraction for it.

The various affinities which theſe colouring matters poſſeſs with regard to oxygen, light, alkalies, and other chemical agents, might form a branch of chemical inveſtigation, almoſt entirely new, and which muſt prove extremely intereſting and curious.

SECT. II.

Account of the Firſt Attempts for Applying the Oxygenated Muriatic Acid to the Proceſs of Bleaching.

HAVING inveſtigated the action of oxygenated muriatic acid upon colouring matters in general, it occurred that the ſame, or ſimilar effects, might be produced by it upon thoſe vegetable particles which gave colour to cloths and threads, and which are intended to be ſeparated or deſtroyed by the proceſs of bleaching; and I ſhall now proceed to give the reſult of my obſervations upon this ſubject. I ſhall not, however, in this place, confine myſelf to a deſcription of the manner in which the proceſs of bleaching, by means of this preparation, is at preſent practiſed; becauſe I think it may be uſeful, for ſuch as chooſe to make uſe of the proceſs, that an account be premiſed of the imperfect attempts by which I firſt began my operations upon this ſubject.

In my firſt experiments, I employed the oxygenated liquor in a highly concentrated ſtate; and, when exhauſted of its ſtrength, by acting upon the colouring matters, I renewed it repeatedly, until the cloths or thread ſubmitted to its action appeared perfectly white. I ſoon diſcovered, however, that, in this manner of proceeding, theſe ſubſtances became conſiderably weakened and injured in their texture, and that ſome even loſt their ſtrength and coheſion altogether during the proceſs.

In conſequence of theſe obſervations, I employed the liquor in a weakened or diluted ſtate in my next experiments, and thereby ſucceeded ſo far as to bleach the ſubſtances completely, without injuring or altering their texture in the ſmalleſt degree; although, by keeping for ſome time, or more readily by being heated, or by expoſure to the action of an alkaline ley, they were rendered yellow very quickly.

Having reflected maturely upon theſe circumſtances, and having compared them with the ſteps in the ordinary bleaching proceſs, I endeavoured to imitate the effects produced by the common method; as I conſidered, that, in the new proceſs, the oxygenated muriatic acid ought to act upon the ſubſtances ſubmitted to it in a manner analogous to the effects produced upon theſe ſubſtances by expoſure upon the bleaching fields, in the uſual manner of bleaching. The latter is not alone ſufficient for bleaching, but ſeems uſeful and neceſſary, by preparing the colouring particles for being afterwards diſſolved and ſeparated by alkaline lixivia or leys.

With a view to the inveſtigation of this part of the ſubject, I examined the nature of the dews, both ſuch as are precipitated from the atmoſphere, and thoſe which are produced by the nightly tranſpiration of vegetables; and by theſe means I diſcovered, that both are ſo ſtrongly impregnated with oxygen, as to deſtroy the colour of paper faintly tinged with turnſole. It is by no means an improbable ſuppoſition, that the ancient prejudices reſpecting May-dews might have ariſen from an obſervation ſomewhat analogous with this, more eſpecially as, in that month, the tranſpiration of plants is extremely copious *.

From

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* It is a well aſcertained fact, that growing vegetables, in a healthy ſtate, and expoſed to the light, continually tranſpire large quantities of oxygen gas, or vital air.—T.

From all theſe conſiderations I was induced, in my next experiments, to imitate, in ſome reſpects, the ordinary proceſs of bleaching; and, for that purpoſe, I employed ſucceſſive expoſures of the ſubſtances intended to be bleached, to the action of alkaline ley, and oxygenated muriatic acid liquor. By following this plan, I ſucceeded in producing a perfect and permanent white.

Having obſerved, likewiſe, that, towards the latter part of the ordinary bleaching proceſs, the ſubſtances which are whitening are ſteeped for a little while either in ſour milk or ſulphuric acid *, diluted with a large quantity of water,

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* Sulphuric acid is the name adopted by the French chemiſts, inſtead of vitriolic acid, or oil of

water, I imitated this part of the proceſs, and found that the cloth I had bleached by the action of oxygenated muriatic acid, thereby acquired a more perfect, and more beautiful degree of whiteneſs.

After employing, as above, the action of alkaline ley alternately with

oxygenated

of vitriol. This acid is now entirely prepared, for the uſes of commerce and the arts, from ſulphur, by a proceſs which needs not be deſcribed in this place, and is, in reality, ſulphur converted into an acid, by combination with oxygen, or the baſis of vital air. It is therefore more regular, and better adapted for giving clear and inſtructive ideas concerning its nature, to diſtinguiſh it by a name derived from that of its proper baſis, than by one derived from the name of a compound ſalt, into which it enters as an ingredient.—T.

oxygenated muriatic acid, I learned that the latter no longer required to be uſed in a ſtate of concentration, and that it was not neceſſary to leave the ſubſtances long expoſed to its action at each immerſion. By this means I was enabled to obviate two inconveniencies, which muſt otherwiſe have rendered this proceſs impracticable in the way of manufacture.

The firſt of theſe difficulties proceeds from the ſuffocating odour of the liquor, which is extremely diſagreeable, and would even be dangerous, if workmen were long expoſed to it at one time. Owing to this circumſtance, ſeveral perſons, who have attempted to employ this preparation, have been diſcouraged, and induced to deſiſt from its uſe. The ſecond difficulty proceeded from the action of the oxygenated acid weakening the texture of the cloth, when uſed in a concentrated ſtate, or long applied.

Since diſcovering the efficacy of theſe alternate immerſions, I have likewiſe deſiſted from mixing any alkaline ſalt with the oxygenated liquor, which I practiſed in the greater part of my firſt experiments, as related in the Journal de Phyſique for the year 1785.

Such, as I have now related, was nearly the ſituation of my experiments on this ſubject, when I made a few trials in preſence of the celebrated Mr Watt. A very ſlight degree of information ſufficed to a philoſopher, who has been accuſtomed to employ his abilities in cultivating the arts. He ſoon afterwards informed me, by letter from England, that, in a firſt trial, he had bleached five hundred pieces of cloth at the houſe of Mr Grigor, who carries on a very extenſive bleachfield near Glaſgow; and I underſtand the latter gentleman continues to employ the new proceſs *.

About

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* I have made ſome inquiry upon this ſubject, and have been informed, though only by hearſay, that the gentleman here alluded to has been induced, by ſome inconveniencies attending the uſe of the oxygenated muriatic acid, to give it up, and recur to the ordinary proceſs of bleaching. What theſe are, I have not been able to learn with any degree of certainty.—T.

About the ſame time, Mr Bonjour, who had hitherto aſſiſted me in my experiments, a gentleman of great ſagacity, and extenſive chemical knowledge, aſſociated himſelf with Mr Conſtant, calico printer at Valenciennes, for the purpoſe of eſtabliſhing a manufacture, according to the new proceſs, in that city. This project was oppoſed by the prejudices and intereſted views of the bleachers, who dreaded the rivalſhip of the new method, in ſo much that Mr Conſtant was unable to procure a piece of ground at Valenciennes for the purpoſe. By the favour of the Count de Bellaing, he has been, however, ſupplied with a piece of ground every way convenient for the buſineſs ; excepting only, that, being at ſome diſtance from Valenciennes, it may become in ſome degree inconvenient, if, at any future period, an eſtabliſhment ſhould be formed in or near the city.

In the proſecution of this enterpriſe, Mr Bonjour has reſigned the proſpects of advancement which his talents and acquirements juſtly merited in Paris; and has experienced thoſe diſguſts and diſappointments proceeding from oppoſition, and other difficulties, which too frequently occur to ſuch as attempt to introduce new proceſſes in the arts.

He applied to the Chamber of Commerce, not to be recompenſed for his intended ſervices, but merely for protection and aſſiſtance, to enable him to ſurmount the obſtacles and impediments occaſioned by the prejudices, and intereſted oppoſition, of the people of Valenciennes. He required a privilege for ſome years, in Valenciennes and Cambrai, and the country two leagues round, during which he might have the ſole right of employing oxygenated muriatic acid in the proceſs of bleaching, without prejudice to ſuch as choſe to continue the old method, or might even invent new ones, in which that acid was not uſed. At the ſame time, he offered to inſtruct, in all the circumſtances of the proceſs, ſuch as were inclined to employ it elſewhere with the countenance of government.

Had his requeſt been granted, thoſe who had engaged to furniſh the neceſſary funds would have been inſpired with confidence; the eſtabliſhment would have been confined to Valenciennes, inſtead of Courtray, where it now is; and by this time many artiſts might have been formed, under his inſtruction, by whom numerous eſtabliſhments, in different parts of France, might by this time have been formed, without the riſk of thoſe fruitleſs trials, which ſo often throw unmerited diſcredit upon uſeful diſcoveries.

SECT. III.

Manner of Preparing the Oxygenated Muriatic Acid Liquor, or Oxygenated Liquor for Bleaching.

WHEN I began to hope that this acid might be uſefully employed in manufactures, I endeavoured to diminiſh its price, by decompounding common ſalt in the ſame proceſs which is performed for oxygenating its acid; but, either from uſing ſulphuric acid too much concentrated, or from the ingredients being employed in wrong proportions, I could only obtain the oxygenated acid in ſuch ſmall quantities,

ties, that I concluded it was more adviſeable to make uſe of muriatic acid ready prepared, as already pointed out in my firſt Memoirs upon this ſubject. The proportions there directed are, three parts, by weight, of concentrated muriatic acid, which are diſtilled from one part of black oxyd of manganeſe in fine powder.

Soon afterwards, Mr Decroiſille, an able chemiſt of Rouen, then employed in experiments, with the view of erecting a manufactory in that city, which I ſince learn has not been executed, publiſhed in the newſpapers of Normandy, that he had diſcovered a means of preparing the oxygenated muriatic acid, much cheaper than could be done by the proceſs I had pointed out. This determined me to repeat my former attempt; and having entruſted the experiment to Mr Welter, a young and ingenious chemiſt, he obſerved, that it might be uſeful to dilute the ſulphuric acid employed: The operation, when conducted in this way, ſucceeded in the moſt ſatisfactory manner. I immediately communicated theſe circumſtances to Mr Bonjour and Mr Watt; and was informed by the latter, that he had employed the ſame means almoſt from his firſt trials. A conſiderable time afterwards, Mr Chaptal deſcribed the ſame proceſs, in a Memoir which he tranſmitted to the Academy of Sciences.

Mr Watt had likewiſe ſubſtituted a caſk, the manner of conſtructing which

I am unacquainted with, inſtead of the apparatus of Woulfe, which I had employed; but, before Mr Watt communicated this circumſtance to me, Mr Welter contrived an apparatus, which, beſides being exceedingly commodious for preparing oxygenated muriatic acid, is very well adapted for ſeveral other chemical operations. I ſhall now give an account of this apparatus, as ſtill farther improved by Mr Mollar; referring to the plate, and explanation, at the end of this Eſſay, for the particular detail of its parts.

The intention of this apparatus is to increaſe the ſurfaces of contact between the gas and the water, as it is only by means of theſe ſurfaces that they can combine together. That part of the gas, which has not entered into combination with the water in the lower ſpace, into which it is firſt conducted from the diſtilling veſſel, eſcapes into the upper cavity, by means of a tube intended for that purpoſe.

The intermediate jar, which is placed between the caſk and the matraſs, is intended to condenſe and retain any muriatic acid which may diſtil over without being oxygenated. This jar contains a ſmall quantity of water, into which a glaſs tube, open at both ends, is plunged, which muſt be of ſuch length as to exceed in heighth the column of water which the gas has to overcome in its paſſage into the caſk. The gas, which paſſes from the matraſs into the intermediate jar, compreſſes the water in this tube, with a force equal to the reſiſtance it meets with in getting into the caſk; by this means the water is forced into the upright tube, ſo as to form a column equal in heighth to that which preſſes upon the tube by which the gas is carried into the caſk.

If, during the proceſs, any ſudden refrigeration, or rapid reabſorption of the gas occurs, the water falls down again from the tube into the intermediate jar, and the atmoſpheric air is allowed to get in, by which means a vacuum is prevented in the diſtilling veſſel. Without this precaution, the liquor might be forced back into the matraſs, by which it would infallibly be broken in pieces. This contrivance, which was invented by the ingenious Mr Welter, is likewiſe moſt uſefully applicable in a great many other pneumatic diſtillations, as is ſhown by an example in the plate.

When we are provided with good oxyd of manganeſe, in ſmall cryſtals, containing very little foreign matter, the following is what I have found, by repeated trials, to be the moſt convenient proportion of the ingredients for the production of oxygenated muriatic acid:

Six ounces of black oxyd of manganeſe, reduced to a fine powder;
Sixteen ounces of ſea ſalt *, likewiſe in powder;
Twelve

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* The beſt way for reducing ſea ſalt into powder,

Twelve ounces of concentrated ſulphuric acid; diluted with
Eight ounces of water.

If the oxyd of manganeſe contain any foreign earthy, or metallic matters, its quantity muſt be increaſed in proportion to its impurity. We learn, after the proceſs is completed, whether a ſufficient quantity has been employed; as, in that caſe, a ſmall part will remain not decompounded, and which, conſequently,

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powder, is by roaſting it in an iron veſſel over the fire, till it no longer cracles or decrepitates. This ſeparates all the water which enters into the compoſition of its criſtals, and allows it afterwards to be freely pounded in a mortar. A frying-pan will anſwer the purpoſe extremely well.—T.

conſequently, retains its black colour. By attending to this circumſtance, in the firſt operation with any parcel of manganeſe, we regulate the quantity to be employed in any after proceſſes with the ſame manganeſe.

When any calcareous ſpar * is mixed with the manganeſe, which is readily known by the effervеſcence which takes place immediately when a little ſulphuric acid is added to it, the moſt convenient means of ſeparating the calcareous

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* A large admixture of calcareous matter with the oxyd of manganeſe, will render it extremely inconvenient, and improper for the oxygenating proceſs, by abſorbing and combining with a great proportion of the ſulphuric acid employed, and thereby increaſing the expence conſiderably.—T.

ous matter, is to waſh the manganeſe in dilute ſulphuric acid, and afterwards dry it: We thus avoid being troubled with any effervescence during the proceſs.

When the manganeſe contains a conſiderable quantity of azote *, it is, in my

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* By *azote*, in the new chemical nomenclature, is meant the ſolid baſis of azotic gas, formerly called *phlogiſticated air*, or *atmoſpherical mephitic gas*. A little of this, which is attracted, probably, from the atmoſphere alongſt with the oxygen gas, is frequently contained, together with ſome carbonic acid, in moſt metallic oxyds. When the oxyd of manganeſe is found, upon trial, to contain any conſiderable quantity of azote, it is readily freed from it, by expoſure for ſome time to a temperature a little below the red heat. This lower degree

my opinion, ill calculated for the purpoſe of oxygenating the muriatic acid.

It is requiſite to employ a larger or ſmaller quantity of water than is mentioned above, in proportion to the degree of concentration of the ſulphuric acid, and according to the quantity of ingredients ſubmitted to diſtillation. When the materials are in conſiderable quantity, the acid muſt be more diluted than in the contrary caſe.

It were cheaper to employ ſulphuric acid, which has not undergone the proceſs

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of temperature forces off the azote in form of azotic gas, without affecting the oxygen, which can only be driven off by heat accompanied with light, or what is called the *red heat*.—T.

ceſs for concentration *, providing that it can be had in that ſtate upon the ſpot; otherwiſe, the concentrated ſulphuric acid is cheaper, as being leſs expenſive to carry from any diſtance.

When

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* The ſulphuric acid is prepared by burning ſulphur with a certain proportion of ſaltpetre, in chambers lined with lead, and containing a ſmall quantity of water, to facilitate its condenſation. In this firſt proceſs, it is conſiderably diluted by the water employed; and, beſides, contains a quantity of ſulphur, not thoroughly acidified, in the ſtate of volatile ſulphurous acid. This is the ſtate of the acid here meant, as moſt economical, when the two manufactories happen to be near. It is converted into concentrated ſulphuric acid for the market, uſually called *oil of vitriol*, by a ſubſequent diſtillation, which ſeparates a great part of the water, and the whole volatile part of the acid.—T.

When the materials are ready, the oxyd of manganeſe, and common ſalt, both in fine powder, muſt be accurately mixed together, and introduced into the diſtiiling veſſel, which has been previouſly placed in a ſand bath. The ſulphuric acid, previouſly diluted with the preſcribed quantity of water, and allowed to cool *, is then to be poured on the other ingredients; and the tube, intended to convey the gas from the matraſs to the intermediate jar, muſt be quickly adapted to the openings of both veſſels, taking care to ſecure the junctures in the moſt effectual manner, to prevent any of the gas from being diſſipated.

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* The meaning of this caution is, that, during the mixture of concentrated ſulphuric acid with water, a very conſiderable quantity of heat is generated, which excites a high temperature in the mixture, or diluted acid. This is produced in conſequence of a large quantity of the matter of heat, called *caloric* in the new chemical nomenclature, being changed to the free or ſenſible ſtate, from the latent or combined ſtate, in which it previouſly exiſted in the water; owing to the water being made to undergo

The proportion between the pneumatic caſk and the matraſs, ought to be

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undergo a conſiderable condenſation while it unites with the ſulphuric acid. If the acid were poured upon the other ingredients in the matraſs in this ſtate, it would, from its high temperature, occaſion ſo quick a production and diſengagement of the oxygenated muriatic acid gas, as to riſk the diſſipation of a conſiderable portion of it before the apparatus could be got into proper order.—T.

be ſuch as to admit of twenty-five gallons of water being contained in the caſk, beſides leaving an empty ſpace, equal to two gallons and a half, which will allow the water to riſe up in the caſk, when it is diſplaced, by means of the gas, from under the inverted buckets, intended, as expreſſed in the engraving, for containing the diſengaged gas.

The caſk being filled with water, in this manner, before the proceſs commences, and the ingredients being mixed together in the matraſs or retort, the gas, as it becomes diſengaged, drives before it the atmoſpherical air of the apparatus, through the tube of communication, into the inverted buckets: When this ſeems all driven out from the matraſs, intermediate jar, and tubes, it is drawn out of the buckets by means of the bent tube repreſented in the plate. This muſt be ſucceſſively introduced below each bucket; and the water which gets into the tube being forced out, by blowing ſtrongly through it with the mouth, the atmoſpherical air will eſcape, and leave the buckets full of water.

The proceſs is now to be continued without fire, ſo long as the gas comes over with any tolerable rapidity. When the bubbles of gas begin to come over ſlowly, a gentle fire is to be lighted in the furnace, which muſt be gradually increaſed by little and little, ſo as to bring the matters to boil, towards the end of the proceſs.

The approaching completion of the operation is indicated by the tube of communication from the matraſs, and the intermediate jar, becoming hot. When this happens, and the diſengagement of the gas has become very ſlow and ſcanty, the fire is to be withdrawn; and, allowing the matraſs to cool, the lute muſt be removed from the junctures, and the veſſels ſeparated; having, in the firſt place, poured a quantity of boiling water upon the remaining ingredients in the matraſs, ſufficient for diſſolving them, by which means they are more readily withdrawn from the matraſs.

This diſſolved reſiduum from the diſtillations muſt be ſet apart in a proper veſſel, and reſerved for a purpoſe which I ſhall afterwards explain.

The operation, when carried on with the quantities of ingredients mentioned above, laſts from five to ſix hours; but muſt neceſſarily take a longer or ſhorter time, in proportion to the quantity of ingredients employed in one diſtillation. One workman can, at the ſame time, very readily conduct ſeveral ſets of diſtilling apparatus, of much larger dimenſions than the one here deſcribed.

During the proceſs, the intermediate jar gradually fills with pure, though dilute, common muriatic acid; but the one belonging to the apparatus in the engraving at the end of this Eſſay, will admit of ſeveral proceſſes, without needing to be emptied. When it ſeems ſo full as not to leave ſufficient ſpace for a ſubſequent proceſs, the acid muſt be withdrawn by means of a ſyphon; and, when a conſiderable quantity of this common muriatic acid is collected, it may be employed in the proceſs inſtead of ſea ſalt and ſulphuric acid *, provided there be no other purpoſe to which

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* When the muriatic acid which collects in the intermediate jar is to be applied to this purpoſe, the proceſs for obtaining the oxygenated acid muſt be conducted with it and oxyd of manganeſe, without any other ingredients, in the manner deſcribed at page 83. of this Eſſay; only, as the muriatic acid procured in this way is very weak, it muſt be uſed in nearly double the quantity there preſcribed.— T.

which the operator can apply it more profitably *.

On purpoſe to leſſen the quantity of common muriatic acid which eſcapes unoxygenated from the matraſs, the tube

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* There is another uſe, to which, in my opinion, it might be very conveniently applied, viz. as a ſubſtitute, properly diluted with water, for the weak ſulphuric acid, afterwards, in this Eſſay, preſcribed for waſhing the bleached ſubſtances towards the end of the bleaching proceſs. I am the more readily induced to point out this way of employing the muriatic acid, obtained during the oxygenating proceſs, as I know that ſeveral bleachers have uſefully applied common muriatic acid, in the ordinary proceſs of bleaching, inſtead of the ſulphuric acid, which is now in almoſt univerſal uſe.—T.

tube which carries it to the intermediate jar ought to form a right angle, or even an obtuſe one, with the neck of the matraſs *.

During the progreſs of the diſtillation, it is neceſſary, from time to time, that the *agitator*, belonging to the pneumatic caſk, or oxygenated liquor tub, be ſet in motion, by turning its handle briſkly backwards and forwards: This agitates the water and gas which are in contact, and greatly promotes the abſorption of the gas by the water, as it preſents new ſurfaces of contact, and intimately mixes, through the maſs of water, any of the liquor which happens to be already ſaturated.

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* In the engraving, at the end of this tranſlation, I have ventured to make ſome ſlight alterations from the figures of the author; and, amongſt others, the one here pointed out, by which the common muriatic acid, as being more readily condenſible than the oxygenated, may be conducted back to the matraſs, if any of it condenſes in this tube.—T.

When the proceſs has been carried on in the manner, and with the proportions of the different materials, and of water in the caſk, as above directed, the oxygenated liquor procured will be found of a proper degree of ſtrength for being employed in bleaching. Or, if it be thought more adviſeable, the oxygenated liquor may be formed, at firſt, conſiderably ſtronger, and more concentrated, by uſing either a ſmaller proportion of water in the caſk, or a larger proportion of ingredients in the matraſs *. In this caſe, the oxygenated liquor can be afterwards diluted to a proper ſtrength for uſe, by adding water to it in the neceſſary proportion.

When the oxygenated liquor is prepared, as above directed, of the degree of ſtrength proper for bleaching, although it ſtill retains a very penetrating, and

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* When the oxygenated liquor is to be uſed in bleaching immediately, by the perſon who prepares it, I would adviſe that it be formed at firſt of the proper degree of ſtrength for uſe, by employing the water in the caſk, and ingredients in the matraſs, according to Mr Berthollet's proportions. But, if the liquor is to be prepared by one manufacturer, and carried to another for bleaching, it is certainly moſt adviſeable to prepare it as much concentrated as poſſible; as, in this way, conſiderable expence of carriage may be ſaved.—T.

and ſomewhat offenſive ſmell, it can neither prove hurtful, nor even conſiderably inconvenient, to the workmen. It is, however, adviſeable, for the purpoſe of avoiding any ſlight degree of incovenience it may ſtill produce, that it be run off from the plug hole of the liquor caſk, through wooden gutters, directly into troughs or vats, where the cloth or thread, intended to be bleached, are already properly arranged for being ſubmitted to its action.

It is likewiſe proper to draw of the oxygenated liquor from the caſk as ſoon after its preparation as poſſible; becauſe it acts upon the wood, and is thereby, in ſome degree, weakened itſelf, and likewiſe tends greatly to haſten the deſtruction of the caſk *: But, when it is run off into the troughs, where the bleaching ſubſtances are ready arranged, it becomes quickly weakened by acting upon them, and is thereby prevented from producing any ſenſible action upon the wood of theſe troughs.

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* For this reaſon, the caſk ought to be filled with water immediately after the oxygenated liquor is drawn off. This will preſerve the ſmall remains of oxygenated liquor adhering to the caſk, and its interior apparatus, and will, at the ſame time, prevent that reſiduum from acting ſo as to injure the wood.—T.

SECT. IV.

Manner of Applying the Oxygenated Liquor in the New Bleaching Proceſs.

BEFORE commencing the bleaching proceſs, the cloth muſt be prepared, by ſteeping it twenty-four hours in water, on purpoſe to extract the dreſſing it received in the loom; or, what will anſwer this purpoſe better, ſome old alkaline ley, which has loſt its ſtrength by former uſe in the after parts of the bleaching proceſs, may be ſubſtituted inſtead of the water. It muſt, in the next place, be expoſed once or twice to the action of ſome good freſh alkaline ley; becauſe all the colouring matter that is capable of being ſeparated from the cloth, by means of ley, would otherwiſe conſume, unneceſſarily, a conſiderable part of the oxygenated liquor, which ought to be very economically employed in the bleaching proceſs.

The cloth muſt then be carefully waſhed with water, to ſeparate any remains of the ley, which might weaken the action of the liquor, and then it muſt be properly diſpoſed in wooden troughs, in ſuch a manner that it may be completely impregnated with the oxygenated liquor, without any part of it being preſſed together, or tightened, ſo as to prevent the liquor having free acceſs all through it. The troughs or vats uſed in this part of the operation, and the tub or caſk employed in the proceſs for making the oxygenated liquor, muſt all be conſtructed without any iron; becauſe this metal is very readily calcined, or reduced to an oxyd, by oxygenated muriatic acid, and in that ſtate will produce ſtains upon the cloth, which can only be taken out by means of ſalt of ſorrel *.

This firſt immerſion in the oxygenated liquor ought to continue for about

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* This acid ſalt is uſually ſold in the chemiſts ſhops under the name of *ſalt of lemons*, though, in reality, a kind of tartar, or acidulous ſalt, extracted from ſorrel, compoſed of the oxalic acid combined in exceſs with vegetable alkali, or potaſh, called in the new nomenclature, *acidulous oxalat of ſoda*.—T.

bout three hours; after this the cloth is to be removed, and the liquor wrung out of it. It is then to be a ſecond time waſhed in alkaline ley; and, that being waſhed out with water, as before, it muſt be again properly placed in a trough, and covered over with freſh oxygenated liquor.

The ſecond, and all the ſubſequent immerſions in the oxygenated liquor, muſt only laſt for about half an hour. The cloth, after remaining about half an hour in the trough, muſt be taken out, and wrung as before, and again waſhed in ley. The ſame liquor may ſerve for ſeveral repeated immerſions, except that which was uſed in the firſt, until entirely exhauſted; taking care, that, when it appears too weak, it be rendered of a proper ſtrength, by the addition of a ſufficient proportion of newly prepared liquor.

When the cloth appears to have acquired a proper degree of whiteneſs, excepting only ſome few black threads and the ſelveges, it muſt be filled with black ſoap, and ſtrongly rubbed for ſome time; after which, it is again to be waſhed in alkaline ley, and to receive one other immerſion in the oxygenated liquor.

It is difficult to determine, *a priori*, what ought to be the preciſe number of immerſions in the liquor, and waſhings with ley, as this is liable to conſiderable variation, according to the nature of the cloth, and its materials. In general, however, from four to eight of each are ſufficient for cloths made of flax or of hemp.

SECT.

SECT. V.

Of the Preparation and Employment of Alkaline Ley in the New Bleaching Proceſs.

FROM want of ſufficient experimental knowledge, I cannot pretend to direct, with certainty, in what manner the alkaline ley ought to be prepared, ſo as beſt to ſerve the purpoſe in bleaching, according to this new proceſs. This very uſeful and neceſſary operation has hitherto been directed merely by cuſtom, without any certain rule; and is even variouſly practiſed in different parts of the country.

I can only ſay, that, ſo far as I have been able to aſcertain, it ſeems of great advantage that the alkali be made cauſtic *, by having one third its weight of quick-lime mixed with it, before the water of ſolution is poured on. It is abſolutely neceſſary, however, when this is practiſed, that the ley be filtered through a coarſe linen cloth, to prevent

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* The effect of the quick-lime, in rendering an alkali cauſtic, depends upon the greater affinity of carbonic acid, or fixed air, to calcareous earth, than to alkali. The alkali, when deprived of its carbonic acid, becomes greatly more powerful, as a ſolvent of ſuch oily and reſinous particles as are preſent in the cloth, and render it foul; and, conſequently, with proper precautions, muſt be greatly preferable, in bleaching, to alkali in its ordinary mild and leſs active ſtate, ſaturated to a certain degree with carbonic acid.—T.

vent any particles of the lime from being mixed with it; becauſe, if any of theſe particles were to get into the cloth which is bleaching, it might be corroded, and injured in its texture, by the hardneſs and acrimony of the lime.

By this manner of preparation, the ley is rendered greatly more active and efficacious, ſo as, of conſequence, not to require being made ſo ſtrong of the alkali as would otherwiſe be neceſſary; and yet, providing it be not made too ſtrong, notwithſtanding the popular prejudice againſt its uſe in bleaching, the cloth does not ſuffer from it the ſmalleſt injury. I have, beſides, remarked, that it is both uſeleſs, and even hurtful, to ſuffer the cloth to remain long in the ley, but that the ley ought to be very hot, and of a ſufficient ſtrength, as, otherwiſe, cloths which have been whitened by the oxygenated liquor are liable to become of a reddiſh colour, when again expoſed to the action of the alkaline leys. In the experiments which I am about to mention, this circumſtance took place.

Mr Caillau made numerous experiments, at Paris, upon the new bleaching proceſs, chiefly with cotton cloths, which are much more eaſily bleached, and require much fewer of the alternate immerſions in ley and oxygenated liquor than thoſe which are made of flax or of hemp. He afterwards went to St Quentin, where he operated, in the large way, upon the cloths of that diſtrict;

ſtrict; but he there found, that, though all the cloth he had whitened gave great ſatisfaction to the manufacturers, with regard to its colour and texture, yet it recovered its brownneſs, in ſome degree, either when paſſed through common ley, or when left for ſome time in the warehouſe. The ſame circumſtance happened with all the cloths which were bleached by Mr Decroiſille at Rouen; and I obſerved the ſame change to take place upon ſuch remnants as had been whitened in my laboratory. At the ſame time, however, Mr Bonjour of Valenciennes, and Mr Welter of Lille, inſiſted, that ſuch cloths and threads, as had been bleached by them, preſerved their colour and whiteneſs completely, in every trial to which they were ſubjected.

I ſoon after diſcovered, that the imperfections of my bleaching proceſs proceeded from the improper manner in which I had employed the alkaline ley. In the experimental trials made in my laboratory, I only heated the ley, and poured it, when hot, into a veſſel, where the ſmall pieces of cloth were ſubmitted to its action. In this veſſel, the ley quickly became cool, and, conſequently, was unable to act with ſufficient efficacy; but, when I kept the ley at a degree of heat approaching to the boiling point, for the ſpace of two or three hours, I found that it then acted with proper power, and was no longer ſubject to the inconveniencies I had before encountered. Hence it appears, that the accidents which had occurred to Meſſrs Caillau and Decroiſille,

ſille, and to myſelf, were entirely owing to the weakneſs, and too great coldneſs of the leys we employed.

To be aſſured that the ſubſtances we have bleached, according to the new proceſs, are ſufficiently and permanently whitened, it is requiſite that they ſhall not have ſuffered any change of colour, in conſequence of the laſt ley to which they have been ſubjected. This is the proper teſt of their being completely bleached; but it is proper, after coming out of the laſt ley, that they be again ſteeped for a few minutes in the oxygenated liquor.

SECT. VI.

Of the Preparation and Employment of Acidulous Liquid, or Dilute Sulphuric Acid, in the New Manner of Bleaching.

IMMEDIATELY after the laſt immerſion, the cloth muſt be plunged into ſour milk, or into water acidulated, to a proper degree, with ſulphuric acid*.

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* From ſome experiments, inſerted in the laſt ſection of this Eſſay, it might be worth while to try whether the ſulphurous acid would act more effectually than the ſulphuric upon the bleached ſubſtances, ſo as to remove any remains

I am not perfectly acquainted with the proper proportions of ſulphuric acid and water for this operation; but I believe, that one part, by weight, of the acid, diluted with fifty parts of water, may be uſed with ſafety; and that this liquor will ſucceſsfully anſwer the purpoſe it is intended for *. The bleached

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remains of colour left by the oxygenated liquor. I have, in another note, explained the difference between theſe two acids: Thoſe who wiſh for more particular information, may conſult Lavoiſier's Elements of Chemiſtry.—T.

* It is of the utmoſt conſequence that the water and acid be mixed together with the greateſt accuracy; for the ſulphuric acid, being greatly heavier than water, falls to the bottom; and, if ſufficient care be not taken, the

bleached ſubſtances muſt be kept immerſed in this acidulous liquid, about milk warm, for near half an hour; after which they are to be ſtrongly wrung, and inſtantly plunged into water; for, if time were given for any evaporation to take place, the ſulphuric acid would become concentrated, in conſequence of the water flying off, and the bleached ſubſtances would thereby be infallibly injured in their texture.

One uſe of the dilute ſulphuric acid, employed as above, is to carry off any particles of iron which may adhere to the bleached ſubſtances, and which tend greatly to injure their colour, eſpecially upon

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the acidulous liquid is apt to be ſtronger at the bottom, and will conſequently injure the cloth.—T.

upon keeping them for any time. When the ſubſtances have been well waſhed in cold water, to ſeparate all the ſulphuric acid, they require no farther preparation, except being dried, and dreſſed * up in the ordinary manner, according to their ſeveral natures.

It is of the utmoſt conſequence to prepare the acidulated liquid with great care; as, when too ſtrong of the ſulphuric acid, it may injure the cloth, and other ſubſtances, very materially: Indeed, to inattention to this circumſtance, I am diſpoſed to attribute the following accident. A parcel of cloths were ſent to Mr Bonjour, on purpoſe to

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* Theſe dreſſing operations uſually are, ſtarching, beetling, calendering, and lapping. —T.

to make trial of the efficacy of the new proceſs for bleaching; upon theſe he performed two diſtinct proceſſes; one of them being adapted for bleaching the finer kinds, ſuch as cambricks, lawns, &c.; and the other for coarſer kinds of goods. The bleaching of the former ſucceeded perfectly in every reſpect; but the perſon whom Mr Bonjour had employed to acidulate the water with ſulphuric acid, for the coarſer goods, having put in, for a ſmall quantity of cloth, ſuch a portion of acid as had uſually been made uſe of for a much larger, the cloth was very conſiderably weakened in its texture; which had never before happened in all the bleaching operations, which had been performed by him for more than a year before.

SECT VII.

Of the Manner of Employing the Oxygenated Liquor, for Bleaching Cotton and Thread.

THE bleaching of cotton cloth is greatly more eaſy, and leſs tedious, than that of ſtuffs made of flax or hemp. Two, or at moſt three leys, with an equal number of immerſions the oxygenated liquor, are ſufficient for rendering theſe perfectly white. And, as they bleach ſo much more readily, it is very convenient and economical, when we have cloths of flax or of hemp, and of cotton, to bleach at the ſame time, to reſerve for the cotton ſtuffs the oxygenated liquors, which have already been weakened by their action upon the linen or hempen cloths. It is of great conſequence, in an economical view, that the power of the oxygenated liquor be exhauſted as much as poſſible; and thoſe which have been already ſo much weakened, by acting upon flaxen or hempen ſtuffs, as to be no longer capable of producing any perceptible effect upon them, are ſtill ſufficiently powerful for whitening goods made of cotton *.

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* There can be no doubt of the propriety of this economical direction; but it muſt be obſerved, at the ſame time, that, as theſe liquors are ſo much weakened, it will neceſſarily require that the goods, to be bleached in this

In the ordinary bleaching proceſs, the whitening of thread is attended with greatly more trouble and inconvenience than that of cloth, in conſequence of the greater number of ſurfaces which muſt neceſſarily be expoſed to the action of the atmoſphere. Even in the new proceſs, by means of oxygenated liquor, a part of theſe difficulties remain, with reſpect to thread; but then, it at laſt turns out more advantageous than even with cloths.

Mr Welter, with two partners, has eſtabliſhed a bleaching manufactory for thread,

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this manner, be expoſed both more frequently, and longer each time, to the action of theſe exhauſted liquors, than if freſh prepared liquor were employed.—T.

thread, at Lille, upon the new principles, which has met with ſo much ſucceſs, that he has already begun two ſimilar eſtabliſhments. He finds, that ſome kinds of thread require ten, or even twelve, alternate expoſitions to alkaline ley and oxygenated liquor; and, on purpoſe that the thread may be entirely ſurrounded with the liquor, he arranges them very lightly, ſo as not to be any way ſqueezed or preſſed together, in baſkets, which are placed in the troughs appropriated for receiving the oxygenated liquor. He finds likewiſe, as I have before mentioned, that, when the liquor has been conſiderably weakened, in conſequence of its action upon linen thread, it may ſtill be very advantageouſly uſed for bleaching cotton thread.

SECT VIII.

Some Miſcellaneous Remarks upon the Subject—The Means of Aſcertaining the Preciſe Strength of the Oxygenated Liquor—Javelle Lixivium—Uſe of the Reſiduum of Diſtillation, &c.

IN my firſt experiments upon the efficacy of oxygenated muriatic acid, for bleaching different ſubſtances, I tried whether it might not be more advantageouſly employed in the ſtate of gas, directly applied to the ſubſtances, than when combined previouſly with water; and I actually found that it acted with conſiderably more quickneſs.

But, in ſpite of every precaution which I could deviſe, there was always a very conſiderable loſs of gas; the parts of the ſubſtances ſubmitted to experiment, which were moſt expoſed to its action, were liable to be greatly weakened in their texture; and it was greatly more difficult to produce an equal degree of whiteneſs over the whole of the ſtuffs. For theſe reaſons, among others, I was induced to deſiſt from uſing it in this manner, and to prefer the proceſs which I have already endeavoured to deſcribe.

On purpoſe to guard againſt every poſſibility of accident or injury to the ſubſtances, which may be bleached according to the new proceſs, from the too great ſtrength of the oxygenated liquor, and to obviate ſuch other difficulties as may occur, from employing it either too ſtrong or too weak, it is of great importance that we ſhould poſſeſs ſome accurate means for aſcertaining its ſtrength; and for this deſireable purpoſe, Mr Decroiſille has contrived a teſt, or gauge, by means of a ſolution of indigo in ſulphuric acid. He takes one part, by weight, of indigo, reduced to a fine powder, with eight parts of concentrated ſulphuric acid, and digeſts this mixture in a matraſs, expoſed to a ſand heat for ſome hours, until the indigo is completely diſſolved by the acid. This ſolution is then diluted with one thouſand parts of water, and is to be employed for meaſuring the force of the oxygenated liquor, as follows:

One meaſure of this teſt ſolution is put into a graduated glaſs tube, and the oxygenated liquor is gradually added to it, until the blue colour of the indigo is completely deſtroyed. We then determine, by means of the degrees upon the tube, how many meaſures are neceſſary, for this purpoſe, of oxygenated liquor, the ſtrength and goodneſs of which has been previouſly aſcertained by direct experiment upon cloth; and this being once found, will ever after ſerve as a ſtandard of compariſon for determining the relative ſtrengths of other oxygenated liquors. Mr Watt employs a ſolution of cochineal for the ſame purpoſe.

While engaged in my firſt experiments upon this ſubject, I was requeſted ed to direct ſome people at Javelle in the method of preparing the oxygenated muriatic acid, and of employing it in the bleaching proceſs. Being extremely deſirous of promoting the extenſion of the new proceſs, I readily went twice upon this errand to Javelle, where I executed the proceſs for preparing oxygenated muriatic acid, in veſſels taken with me for the purpoſe, and whitened ſome pattern pieces of cloth as a ſpecimen of the manner of operating. At that period, I ſtill employed a conſiderably concentrated oxygenated liquor, with which I mixed a ſmall quantity of alkali.

Some time afterwards, the Javelle manufacturers publiſhed advertiſements in ſeveral periodical papers, ſetting forth, that they had diſcovered a particular chemical liquor, called by them the *Javelle lixivium,* which had the property of being able to bleach cloths by means of a few hours immerſion. The only change theſe people made upon the proceſs, which I had executed in their preſence, was by adding ſome alkali to the water before it is impregnated with gas; by this the liquor can be greatly more concentrated than in the ordinary manner, and requires being afterwards diluted with ſeveral times its bulk of water before it is uſed.

By employing the following proportions of ingredients, I ſucceeded in imitating the pretended Javelle lixivium. Two ounces and a half of common ſalt, two ounces of ſulphuric acid, and ſix drams of black oxyd of manganeſe, were put into the matraſs; and in the jar, intended for condenſing the gas, was placed five ounces of potaſh, diſſolved in ſixteen ounces of water. The Javelle liquor has a reddiſh tinge, from its containing a ſmall portion of manganeſe, which either paſſes over in diſtillation, in conſequence of no intermediate jar being employed, or is occaſioned by a ſmall portion of that mineral, uſually contained in the potaſh.

This liquor may be diluted with from ten to twelve times its bulk of water, and will even then bleach or whiten ſuch ſubſtances as are expoſed to it more quickly than the ſimple oxygenated liquor, which has been deſcribed in the former ſections of this Eſſay. But, without noticing the other imperfections of the proceſs deſcribed by the manufacturers of Javelle, this method of preparing the oxygenated liquor is only adapted for bleaching cotton; and, beſides, from the oxygenated muriatic acid being in part combined with alkali, its power of action is ſo much diminiſhed, that it is not capable of acting upon nearly the ſame quantity of cloth, as if ſimply united to water, in the manner already recommended.

It is evident, that, in this manner of preparing the liquor, a part of the oxygenated acid combines with the potaſh to form a neutral ſalt, totally unknown to former chemiſts, which is called *oxygenated muriat of potaſh*. In this ſalt, the oxygenated muriatic acid is ſaturated or neutraliſed by the alkali, and, conſequently, in great meaſure, deprived of its power of acting upon coloured and colouring ſubſtances; for all, or moſt of the oxygen, which enters into the compoſition of this neutral ſalt, becomes uſeleſs in the bleaching proceſs. Of this we have complete evidence, from a circumſtance which I formerly took notice of, in a Memoir upon ſome of the chemical combinations of the oxygenated muriatic acid, that the oxygenated muriat of potaſh has no action whatever upon colours.

In the Memoir above referred to, which is printed in the collection of the Turin Academy, I have given a detailed account of the phenomena preſented by potaſh, combined with the oxygenated muriatic acid, to which, for farther particulars, I muſt refer my readers.

To theſe objections I may add, that the expence of the potaſh, employed in this proceſs for concentrating, and in part deſtroying the efficacy of, the oxygenated acid, is entirely thrown away. Notwithſtanding of all theſe objections, one of the original eſtabliſhers of the Javelle proceſs, having gone over to England, has had the effrontery to demand an excluſive privilege for the preparation and ſale of the Javelle liquor, as a *new invention* of his own.

I flatter myſelf, that the information I have given in this Eſſay, may be ſufficient for directing ſuch as are inclined to undertake the trial of the new bleaching proceſs. Experience will undoubtedly improve our knowledge of the ſubject, and bring us nearer towards perfection; and I undertake to give public notice of every improvement upon the proceſs which may come to my knowledge.

There is one very important point, upon which I cannot at preſent explain myſelf particularly, becauſe the proceſs was invented by another, and has only been communicated to me as a ſecret. It is the means of ſeparating, from the reſidua of the different diſtillations, which I directed to be preſerved for this purpoſe, the ſoda *, which formed part

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* The reſiduum of the diſtillation conſiſts

principally

part of the common ſalt employed to produce the muriatic acid.

Mr de Morveau has made ſeveral experiments with this view, by my deſire, upon the reſiduum, the reſults of which he has communicated to me; and, from his firſt eſſays, he has reaſon to

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principally of two neutral ſalts; the one is the ſulphuric acid employed in the proceſs, united with the ſoda of the ſea ſalt; the other is compoſed of part of the muriatic acid of the ſea ſalt, united with the mangneſe. I ſhould not conceive it a difficult matter to ſeparate the former of theſe, which, under the name of *Glauber's ſalt*, gives a very good price in the market; but, as I have not had any opportunity of trying experiments on the ſubject, I ſhall not obtrude any theoretic plans for the purpoſe, though I intend to make the attempt as ſoon as poſſible.—T.

to conclude, that the advantages which may be derived from the ſoda, in this manner, may be ſufficient to pay almoſt the whole expence of the proceſs for preparing the oxygenated liquor; ſo that this new proceſs for bleaching will be reduced to very little more than the expence of preparing the alkaline leys. I am acquainted with ſeveral proceſſes proper for being employed with this view; but, having been communicated to me as ſecrets, I do not feel myſelf at liberty to diſcloſe them.

It would be of great advantage to the bleaching buſineſs, according to this new method, if the proceſs for making ſulphuric acid could be conjoined in the ſame manufactory; as, by this means, the ſulphuric acid, which is the heavieſt part of the expence in producing the oxygenated liquor, could be procured a great deal cheaper than when purchaſed from the preſent manufacturers of that acid; more eſpecially as, in this way, the ſecond proceſs, by which the ſulphuric acid is concentrated, might be ſpared.

There is great reaſon to hope, that the proceſs by which the ſulphuric acid is prepared will ſoon be brought to perfection, by leaving out the uſe of nitre, and by diminiſhing the loſs of acid in vapour *. By theſe means, and by

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* We are referred by Mr Berthollet to the Encyclopedie Methodique, page 357. for an account of theſe improvements upon the proceſs

by preparing the neceſſary ſulphuric acid in the bleaching manufactory, the price of the oxygenated liquor will be reduced almoſt to nothing.

In addition to theſe advantages, we may hope to ſee the application of the leys brought to perfection, by the uſe of proper machinery. And beſides, when the action of the alkaline ley is entirely exhauſted, in conſequence of its alkali being ſaturated with extractive matter, or with colouring particles, or both, it might readily be recovered again, eſpecially in countries where feuel is cheap, by evaporatimg the ſpent ley to dryneſs, and calcining the ſalt, ſo as to deſtroy ſuch

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ceſs for preparing the ſulphuric acid, which muſt be of infinite conſequence to many of our manufactures.—T.

ſuch matters as have combined with it during its action upon the bleaching ſubſtances.

SECT.

SECT. IX.

Advantages which may naturally be expected to follow the Introduction of the New Proceſs for Bleaching.

IF at preſent, when the expence of the oxygenated liquor amounts only to one halfpenny per gallon *, in ſuch provinces of France as are not ſubject to the *gabelle* upon ſalt, it is found adviſeable to employ the new bleaching proceſs, when properly conducted; there can be no doubt that it muſt become vaſtly more advantageous, when combined with theſe economical plans of management which I have juſt now pointed out. But, ſo long as the oxygentated liquor continues to be any thing dear, there muſt remain a very conſiderable preference in favour of the finer ſtuffs, with regard to the new bleaching proceſs; becauſe theſe not only preſent a much ſmaller quantity of matter to be whitened in the ſame number of yards than coarſe cloths, but are even much more eaſily bleached; hence one yard of fine cloth requires a conſiderably ſmaller quantity of oxygenated liquor to bleach it than is neceſſary for a yard of coarſe cloth; and one pound of fine ſtuff requires leſs than is requiſite for bleaching a pound of coarſe cloth.

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* In the original, it is three deniers the Paris pint. The Paris pint is ſomewhat more than double the Engliſh; and I believe the denier is about one-ſixth of an Engliſh farthing.—T.

To reap the fulleſt advantages which may be derived from the new method, it ought neceſſarily to be eſtabliſhed in a country which is not ſubject to the tax upon common ſalt *; for it is very evident, that, unleſs ſalt can be procured at a low price, the oxygenated liquor muſt become too expenſive for general uſe. With a view to obviate this difficulty, the Board for encouraging

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* This obſervation points out the propriety of a very neceſſary regulation in Britain: As ſalt is free from duty in Ireland, our manufacturers muſt loſe eventually in a competition with thoſe of our ſiſter kingdom, unleſs ſome precautions be uſed for furniſhing ſalt at an eaſy rate to the Britiſh bleacher.—T.

ging the Arts at Rouen, has propoſed that ſalt ſhould be furniſhed at a low price to the bleachers, being previouſly rendered foul, by mixing with each hundred weight of ſalt one pound of martial vitriol. By this means its colour and taſte are ſo effectually contaminated, as to be readily diſtinguiſhable, and the ſalt becomes totally unfit for ordinary uſes. And the means by which ſalt, that has been mixed in this manner, can be refined, ſo as again to render it fit for uſe, are ſo expenſive and troubleſome, as to render it altogether impracticable, with any fraudulent view. To theſe precautions, proper inſpection, under the revenue officers, might be added, ſo as effectually to prevent any poſſibility of fraud.

It is not, however, ſolely by forming a rigorous compariſon between the expence of the new and of the old methods of bleaching, that we are to judge of the intrinſic merits of the new proceſs, or to pronounce that it is more or leſs advantageous than the ordinary method. There are other conſiderations which might juſtly give it the preference, were it even found ultimately to be attended with a little more expence than the old method of bleaching.

In the ordinary method, it uſually requires ſeveral months to bleach cloths and threads, which, by the new proceſs, may very readily be accompliſhed in five or ſix days, even in a large eſtabliſhment; for, in the ſmaller way of experiment, the proceſs of bleaching may be finiſhed in two or three days, without hurry or difficulty. The new method may likewiſe be practiſed during winter with equal facility as in ſummer, whilſt the ordinary method can only be followed during the ſummer months. The drying of the ſubſtances which have been bleached is the only part of the new proceſs which will require a little longer time during winter.

At preſent, the lower order of people in the country, who employ their leiſure from ruſtic labour in ſpinning *, are

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* It is curious how much reſemblance there is in this circumſtance between the lower order of the people in France and in Scotland, owing,

are obliged to wait the proper ſeaſon for ſending their threads or cloths to the bleachfield, which is often at a great diſtance, and which always requires a long time for bleaching their goods. In the mean time, being preſſed by their

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owing, moſt probably, to the intimate connection which formerly ſubſiſted between the two nations. The private manufacture riſes conſiderably higher in Scotland, as many ladies of high rank, and moſt of the gentry in the country, employ their maid ſervants, and poor neighbours, in ſpinning during winter, and get the yarn manufactured into linen of various kinds for the family uſe. This practice leſſens daily; but, till very lately, by far the greater number of families in Scotland, from the nobility downwards, were entirely ſupplied with every kind of linen by the induſtry of the ladies.—T.

their neceſſitous circumſtances, they are frequently under the neceſſity of ſelling, even at an under value, to intermediate dealers, who thus draw a profit from their poverty. But, if manufactories for preparing the oxygenated liquor were ſufficiently numerous, theſe poor people might be enabled to enjoy the whole profits of their laborious induſtry, by whitening their goods as ſoon almoſt as they are manufactured.

The commercial dealer in theſe goods is often reduced, in conſequence of unfavourable bleaching ſeaſons, to the neceſſity of fulfilling his engagements at a very great loſs; being obliged to fill his warehouſes, at a great expence, during the bleaching ſeaſon, that he may thereby be able to ſerve his cuſtomers through the remainder of the year. He often finds himſelf unable to take advantage of favourable opportunities for ſpeculation, which ſometimes unexpectedly offer, becauſe it would require too long a time to bleach the cloths he has occaſion for, and he is not able to lie ſo long out of his money, for want of ſufficient capital. It is evident that theſe difficulties will vaniſh altogether, or be reduced almoſt to nothing, by the new method, as he can bring his goods to market, fully prepared, in the courſe of a few days.

Even the conſumers of the goods will find advantages from the introduction of the new method of bleaching; ſince, beſides ſome reduction in price, which muſt neceſſarily flow from the more expeditious,

peditious, and leſs expenſive mode of proceeding, it is certain, that, when this method is properly executed, the original ſtrength and ſolidity of the flax and hemp are much leſs diminiſhed than in the ordinary proceſs; and, conſequently, the cloths and threads, bleached in the new way, will laſt much longer than thoſe which were ſubjected to the long and numerous proceſſes of the old method of bleaching. It even appears, by the experiments of Mr Decroiſille, that the oxygenated liquor contracts the pores of cotton, ſo as to add to its ſtrength and conſiſtancy; and that it, at the ſame time, enables it to receive more brilliant colours in the operations of dying and printing.

There is, however, one inconvenience proceeding from the new method, which it is neceſſary to notice. In conſequence of the cloths being leſs worn or injured by the bleaching proceſs, they appear coarſer than ſtuffs of the ſame quality, which have been bleached by the ordinary means. From this circumſtance, Mr Bonjour has been under the neceſſity of contriving means to wear down, or ſoften and injure, in ſome degree, the texture of the cloths which were bleached at his eſtabliſhment. Theſe methods of injuring the texture of the cloths muſt be ſufficiently evident to need no deſcription; but it were better that the buyers could be ſatisfied with having their goods of their full ſtrength; as it needs no argument to prove, that they will more than compenſate,

penſate, by their durability, for what they want in apparent fineneſs.

May I venture to hope, that, by means of the new method of bleaching, which I have had the honour of announcing, thoſe fine and extenſive fields, which, in the moſt fertile regions, are now given up to the occupation of webs, which muſt be ſpread out upon them through the whole of the fine ſeaſon of the year, may thus be recovered to agriculture, from which they are at preſent almoſt totally cut of; and that, by this means, I may contribute to increaſe the means of ſubſiſtance, and, conſequently, the population of my country?

If I do not flatter my imagination, the proceſs of bleaching which I have deſcribed, muſt be reckoned ſuperior to thoſe inventions which only tend to facilitate and improve the progreſs of uſeful arts. It deſerves particular attention from thoſe who watch over the public proſperity, ſince, beſides advancing the intereſts of trade and manufactures, it is directly calculated for increaſing the population and production of the country, which are the primary ſources of national riches and proſperity, and which, upon many accounts, deſerve the utmoſt attention of the patriot and politician.

SECT. X.

Some other Uſeful Purpoſes, in the Arts, to which the Oxygenated Muriatic Acid may be applied.

I MEAN now to enumerate ſome other purpoſes to which the oxygenated muriatic acid may be advantageouſly applied; but reſpecting which I have not hitherto had ſuch opportunities of information and experience, as in the proceſs for bleaching.

There is reaſon to ſuppoſe, that it may be uſefully employed for deſtroying the maddered grounds of printed cloths.

cloths *. When theſe have been printed with different kinds of fixing liquors, they are dyed with madder, by which means the figures imprinted by the ſtamps acquire certain ſhades of colour, according to the nature of the fixing liquor employed. But then the grounds of the cloths acquire the colour of the madder at the ſame time, which muſt neceſſarily be diſcharged; and, as in this place, it is much leſs fixed than upon the parts which have been ſtamped

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* I am ignorant of the technical terms in the cloth printing buſineſs; but there can be no difficulty to underſtand what is here meant by the ground of cloth dyed with madder, and the figures, where the ground is fixed, by being ſtamped with different materials proper for giving ſtability, and the proper ſhade to the dye.—T.

ſtamped with various ſubſtances, intended to fix and vary the colour, it is deſtroyed by means of cow dung and bran, and by long expoſure to the ſun and air in bleaching fields.

I endeavoured to anſwer this purpoſe by means of the oxygenated muriatic acid, but always found that the colours of the ſtamps, which ought to be preſerved, were materially changed by its action. Mr Henry, an able chemiſt of Mancheſter, has diſcovered, that this bad effect of the oxygenated liquor may be ſucceſsfully prevented by means of the carbonates of potaſh, or of ſoda [*]. I am unacquainted with the particulars of Mr Henry's proceſs. Mr Decroiſille informed me, about the ſame time, that he had made a ſimilar diſcovery; and I ſoon afterwards confirmed it, by making uſe of the proceſs I have already deſcribed for imitating the Javelle lixivium, and employing that liquid diluted plentifully with water.

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[*] The ſubſtances here meant are what were, in the old chemical language, called *aërated fixt vegetable*, and *mineral alkalies*; or, for common

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mon uſe in manufactures, the ſubſtances called, in commerce, *potaſh*, and *pearlaſh*, and *barilla*, will ſerve the purpoſe. It is ſufficient, in this publication, to explain ſuch terms as ſeem attended with any difficulties to general readers. Thoſe who wiſh for more particular information reſpecting the new chemical nomenclature, and the reaſons of its authors for ſetting aſide the old language, will find them at full length in Lavoiſier's Elements of Chemiſtry.—T.

I communicated this circumſtance to Mr Oberkampf, who ſeizes every opportunity for improving the beautiful manufacture which he carries on at Jouy. He loſt no time in making trial of the proceſs, which he now continues, with the aſſiſtance of Mr Royer; and it promiſſes to be of excellent uſe with ſuch colours as do not contain iron. Theſe are weakened conſiderably by the oxygenated alkaline liquid; but the red colours, on the contrary, acquire from it a greater degree of brilliancy than from the ordinary proceſs. I am not, however, as yet ſufficiently acquainted with the methods of proceeding, to be enabled to give an account of the particulars of this proceſs.

I have learned lately from Mr Taylor, a celebrated manufacturer of Mancheſter, where the new bleaching proceſs has been lately introduced, that it is not always neceſſary to add an alkali to the oxygenated muriatic acid for the above mentioned purpoſe; and that the colours which contain iron are not always weakened by its uſe. Theſe circumſtances are probably owing to ſome variations in the methods there employed for printing the cloths.

In the trials which have been made at Jouy, the expence of the new proceſs has turned out to be more conſiderable than that of the ordinary proceſs, on account of the high price of ſalt. This is an additional proof of the diſadvantages to which the manufactories of printed cloths are liable, when ſituated in countries where the ſalt tax is eſtabliſhed.

It is probably of more conſequence, in the application of the new method to the calico printing, to be enabled to aſcertain the relative ſtrength of the oxygenated alkaline liquor, than of the ſimple oxygenated liquor for bleaching; but for this particular purpoſe we cannot employ the ſolution of indigo, as formerly directed; becauſe, according to information I have received upon this ſubject from Mr Watt, the alkali, which is mixed with the oxygenated acid for the printing buſineſs, in a great meaſure defends the indigo, ſo that its colour becomes only imperfectly deſtroyed by the action of the oxygenated muriatic acid. We are ſtill, however, in poſſeſſion of another teſt, or means for determining the force of action of the oxygenated alkaline liquor, as Mr Watt has found that a ſolution of cochineal will anſwer the purpoſe very perfectly.

Both Mr Henry of Mancheſter, and Mr Decroiſille of Rouen, have obſerved, that this oxygenated alkaline liquor may be very ſucceſsfully employed for heightening the colour of cottons which have been dyed with Turkiſh red.

I have formerly ſhown, that, by means of oxygenated muriatic acid, the green vegetable wax * may be bleached; but I

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* This ſubſtance is procured in America, and

I have never been able to render it equal in whiteneſs to bleached bees wax, as it always retained a yellowiſh hue; though, by this proceſs, it is made very nearly to reſemble bleached bees wax in its other properties. I had likewiſe found, that, by the new proceſs, bees wax might be very perfectly bleached; but then, it required to be frequently melted, and to have the oxygenating proceſs ſo often repeated, that I conſidered the old method of whitening it as more generally advantageous, owing to the expence of employing the new

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and other countries, from the berries of the myrtus cerifera, or candleberry myrtle, and is much employed for making candles, fit for the warmer latitudes, and has been of late frequently ſubſtituted, inſtead of bees wax, in the compoſition of plaſters and ointments.—T.

new one. I have ſince learned, however, from the Chevalier Landriani, that Baron Born has diſcovered that yellow bees wax is very readily bleached, when expoſed to the vapours of the oxygenated muriatic acid; and that the Baron intends eſtabliſhing a manufactory for this purpoſe. In this proceſs, the employment of the oxygenated muriatic acid, in the ſtate of gas, does not appear to be attended with the inconveniencies I formerly pointed out, when treating of its application to the bleaching of cloths; and I have little doubt that it may ſucceed in this way extremely well.

In the firſt volume of the Annales de Chymie, we learn from Mr Chaptal, that the oxygenated muriatic acid can be employed with great ſucceſs for cleaning and reſtoring old books, and copperplate engravings, which have been much ſoiled and deſtroyed by time *.

I have already mentioned, in my former Memoirs upon this ſubject to the Academy, that the oxygenated muriatic acid may be very uſefully employed as a teſt of the durability of colours, and for diſcovering, in a moment, what changes they are liable to ſuffer by long expoſure to the ſun and air. A very great number of experiments have thoroughly

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* The information contained in Mr Chaptal's Memoir I have thought proper to add, as a ſupplementary ſection, to this tranſlation, as it may be applied to ſome uſeful purpoſes. —T.

thoroughly ſatisfied me of its uſefulneſs in this reſpect; and I have hitherto diſcovered exceedingly few exceptions to the general rule. Indeed, I am convinced that we ſhall never be miſtaken in this teſt, if an oxygenated liquor, of one uniform degree of ſtrength, be employed, into which ſmall ſpecimens of the colours intended to be tried are immerſed, for a determinate ſpace of time *.

The

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* In the application of the oxygenated liquor, as a teſt of the durability which may be expected from colours, when expoſed to the action of the ſun and air, it ſeems proper that a very dilute liquor ſhould be employed; as, otherwiſe, colours may be bleached, or deſtroyed, by a ſtronger liquor, which would withſtand the ſlow oxygenation produced by

The Baron de Dietrich informs me, that Mr Hauſſman of Colmar has diſcovered, that every kind of colour may be diſcharged from cloths by means of the oxygenated muriatic liquor, if they are afterwards ſteeped in dilute ſulphuric acid, on purpoſe to diſſolve the metallic particles which enter into the compoſition of many kinds of dyes.

It is neceſſary to remark, as I have ſhown in the ſequel of my obſervations upon the ſulphurous acid *, that the oxygenated

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the action of the air, aſſiſted by the ſun, for a very long time.—T.

* The ſulphurous acid is what is called the *ſulphurous acid of Stahl*, or the *phlogiſticated vitriolic acid*. I have added theſe obſervations, extracted

oxygenated muriatic acid gives a yellow colour to animal ſubſtances. This obſervation may very probably be hereafter applied to very uſeful purpoſes; and, from the circumſtances which attend it, I am inclined to believe, that the above mentioned diſcovery of Mr Hauſſman is chiefly applicable to vegetable ſubſtances.

SECT.

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extracted from the Memoir upon ſulphurous acid, to the end of the next ſection.—T.

SECT. XI.

Some Properties of Oxygenated Muriatic Acid, extracted from a Memoir upon this ſubject by Mr Chaptal *.

BY means of oxygenated muriatic acid, Mr Chaptal bleached ſome rags of coarſe ill coloured linen, uſed at the paper mills for making blotting paper; and theſe rags were afterwards worked up into paper of an exceedingly good quality. He computed, that the rags were by this means increaſed twenty-five per cent. in value; and that the expence of the proceſs, when calculated in the ſtricteſt manner, does not exceed ſeven per cent.

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* This ſection is extracted from the firſt volume of the Annales de Chymie. It is there intituled, ' Report to the Royal Academy, of ' a Memoir by Mr Chaptal, concerning ſome ' Properties of the Oxygenated Muriatic Acid; ' tranſmitted for Publication in the Memoirs ' for

Mr Chaptal employs the bleaching quality of oxygenated muriatic acid, to reſtore

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'for 1787, by the Academy of Montpelier.' The report was drawn up by Mr Lavoiſier and Mr Berthollet, and publiſhed in the Annales de Chymie, as containing new and uſeful chemical information. I here ſubjoin it to the tranſlation of Mr Berthollet's excellent Eſſay upon the New Bleaching Proceſs, as it contains information connected with the improvement of the uſeful arts.—T.

reſtore prints which have been ſo much injured by time, that the traces of their outlines were almoſt entirely obliterated, and the proceſs ſucceeded ſo completely, that they appeared after it as if newly wrought off. He employs it likewiſe to remove the yellow colour which books acquire by long keeping, and thereby reſtores them to the original ſtate they were in when firſt printed.

For the reſtoration of prints, it is ſufficient to plunge them into the oxygenated liquor, and retain them in it a longer or ſhorter ſpace of time, in proportion to the concentration of the liquor; but, when old books are to be operated upon, it is neceſſary to have recourſe to ſome more complicated precautions.

cautions. Mr Chaptal has operated in different manners; but it will be ſufficient, in this place, to deſcribe what appears the beſt adapted for the purpoſe.

Having unbound the book, and ſeparated its leaves, he provides a wooden frame, upon which they are laid, having thin ſlips of wood interpoſed between every two leaves; and theſe are faſtened together by means of ſmall wooden wedges, which are driven in between the ſlips and the leaves *. The whole

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* This paſſage ſeems obſcure, though literally tranſlated; but, as the general principles of the operation are ſufficiently diſtinct, there can be no difficulty in applying them to practice.—T.

whole being properly diſpoſed, is immerſed in the oxygenated liquor, and kept there for two or three hours, according to circumſtances. After this, the frame and its contents are taken out of the oxygenated liquor, and plunged into cold water. By this proceſs, the books are not only reſtored to their original appearance, but the paper acquires a degree of whiteneſs which it never poſſeſſed before, even when new. The liquor has, beſides, the valuable property of obliterating any blots, or other marks of common ink, which frequently injure the value of books or prints. It has not, however, power to cleanſe any ſtains of oil or greaſe; but then, we have long known that theſe may be removed by means of a weak ſolution of cauſtic fixed alkali.

Mr Chaptal likewiſe deſcribes ſome experiments which he made for bleaching different pieces of cloth, by means of oxygenated muriatic acid in the ſtate of gas; but, from the experiments which have been made by Mr Berthollet* upon this ſubject, it appears ſufficiently proved, that this method is greatly leſs fit for uſe than that in which the oxygenated muriatic acid is reduced to a liquid form, by combination with water. It appears, that, when uſed in the ſtate of gas, there is a much greater loſs of the oxygenated acid; the cloths are greatly more ſubject to be injured in their ſtrength and texture, and are, beſides, liable to be unequally bleached. From theſe experiments of Mr Berthollet's, it appears, likewiſe, that, unleſs the ſubſtances to be bleached are ſubmitted to the alternate action of oxygenated muriatic acid, and of alkaline leys, they are liable to recover a browniſh hue, either by long keeping, or by means of ley.

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* The experiments of Mr Berthollet, here referred to, are thoſe which are contained in the foregoing ſections of this Eſſay.—T.

In Mr Chaptal's Memoir, there are ſeveral other obſervations upon the oxygenated muriatic acid, of which the two following only are ſelected, as being more intereſting, and more original, than the reſt. If acetous acid, or diſtilled vinegar, be expoſed to air loaded with oxygenated muriatic acid gas, it acquires, in a ſhort time, a flavour ſimilar to that of acetic acid, or radical vinegar, and thereby acquires the property of diſſolving copper, and forming what are called *criſtals of Venus*, which this acid cannot do in its ordinary ſtate, unleſs when ſuperſaturated with oxygen *.

When copper is expoſed to the vapour of oxygenated muriatic acid, it becomes covered with a ruſt, or oxyd, which is eaſily ſeparable, and is ſoluble in acetous acid, and may, by evaporation, be formed into criſtals, which are applicable to every purpoſe in which verdegris is commonly employed. The colour of theſe criſtals is a ſomewhat deeper green than thoſe of common verdegris; but, when the latter has been completely dried by evaporation, the colour of the two are hardly to be diſtinguiſhed from each other.

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* It would much exceed the neceſſary limits of a note, to explain the difference between *acetous* and *acetic* acids, ſo as to be underſtood by thoſe who have not ſtudied the modern chemiſtry. I muſt therefore refer, for information upon this ſubject, to Lavoiſiers Elements of Chemiſtry.—T.

The ſulphurous acid has ſometimes ſo ſtrong an attraction for the oxygen, which is combined with ſome ſubſtances, as to be able to carry it off, and thereby becomes changed to ſulphuric acid. While, on the contrary, the ſuperabundant oxygen, which is contained in the oxygenated muriatic acid, is retained ſo very looſely, that it often reſtores the oxygen to theſe ſubſtances which have been deprived of it by the action of the ſulphurous acid. From theſe circumſtances, I have, in a former Memoir, explained the manner in which the ſulphurous acid reſtores the colour of pruſſiat of iron, or Pruſſian blue, after the colour had been deſtroyed by means of oxygenated muriatic acid *.

Silk, and moſt other animal ſubſtances, are rendered yellow by the action of

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* This, and the two following paragraphs, are extracted from a Memoir of Mr Berthollet's, in the ſecond volume of the Annales de Chymie, and are here added, as containing ſome

of the nitric acid *; and Mr Gmelin has, ſeveral years ago, deſcribed a proceſs of this kind, for giving ſilk a permanent yellow colour. The oxygenated muriatic acid produces the ſame effect; and in both caſes the yellow colour is produced by the combination of oxygen with the ſilk. It is likewiſe extremely probable, that the yellow colour which ſilken goods acquire by long keeping, proceeds from a ſimilar combination

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ſome obſervations that appeared applicable to uſeful improvements in the arts.—T.

* *Nitric acid* is the pale or colourleſs acid procured by the decompoſition of nitre; being thus diſtinguiſhed from the orange coloured volatile acid, obtained likewiſe from nitre, and which, in the new nomenclature, is called *nitrous acid*.—T.

combination with oxygen. The ſulphurous acid deſtroys the yellow colour thus produced by oxygenated muriatic acid, and reſtores the whiteneſs of the ſtuffs *; and I have, by taking advantage of theſe properties, ſeveral times rendered pieces of ſilk yellow and white by turns.

Thus the ſulphurous and oxygenated muriatic acids frequently produce a ſimilar effect upon colours, and coloured ſubſtances, though in conſequence of a directly contrary mode of action. Sometimes the ſulphurous acid is incapable of

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* This obſervation may be very uſefully applied for reſtoring the whiteneſs of ſilk ſtockings, laces, gauzes, and other white ſilk goods, which have grown yellow by long keeping.—T.

of producing the effect, while the oxygenated muriatic acid readily deſtroys the colours; ſometimes the ſulphurous acid reſtores ſuch colours as have been deſtroyed by the oxygenated muriatic acid; and, laſtly, the oxygenated muriatic acid gives a colour to ſubſtances, which may again be diſcharged by the ſulphurous acid. Theſe phenomena depend upon the different affinities which ſubſiſt between theſe two acids, and the coloured or colouring parts of bodies, with oxygen; and we owe to modern chemiſtry the knowledge we poſſeſs of theſe facts, and the means of explaining them in a ſatisfactory manner.

EXPLANATION

OF THE

PLATE.

Fig. 1. Is a view of the apparatus, contrived for preparing the oxygenated muriatic acid liquor, as fitted up, and put together, for uſe. ABCD, is a common reverberatory furnace, having ſeveral openings, ffff, in the dome, to ſerve as chimneys to let out the ſmoke *. In

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* Theſe furnaces may be had at Paris ready made; but I know no advantage to be derived from the particular ſhape repreſented in the

plate,

In the inſide of the furnace, upon the ſand bath, bb, is placed a matraſs, c, the neck of which riſes through the opening, D, at the top of the furnace. This opening muſt be luted very tight with fire clay. The opening, F, of the matraſs, is fitted with a cork, G, through the middle of which paſſes one end of the bent tube, H, which forms the communication between the matraſs and the intermediate jar or bottle, K, where its other end paſſes, in a ſimilar manner, through another cork, I, which cloſes one of the mouths of that

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plate, which will be found very inconvenient, and troubleſome to get conſtructed in this country. A common air furnace, provided with an iron pot, by way of ſand bath, will anſwer equally well, and is much more eaſily procured and managed.—T.

that bottle. Theſe corks, G and I, muſt be previouſly prepared, and properly adjuſted to the two ends of the tube of communication, ſo as to be enabled to form the communication between the matraſs and intermediate bottle, K, immediately after the ingredients are mixed together in the matraſs. This tube of communication, with its two corks, is repreſented, ſeparately, at g i.

The intermediate bottle, K, contains about an eighth part of its meaſure of water, which is intended for condenſing any vapours of unoxygenated muriatic acid which may riſe during the diſtillation. The long tube, L, open at both ends, is plunged to the bottom of this water, and is intended to prevent the dangers and inconveniencies which are apt to ariſe from ſudden refrigeration, or reabſorption of the gas or vapour during the proceſs. This tube, which is called *the tube of ſecurity*, muſt be of ſuch a length, that the weight of the column of water, forced into it by the preſſure of the gas, may be equal to the reſiſtance which the gas meets with in its paſſage from the intermediate jar into the liquor caſk.

N O P, is the pneumatic vat, or liquor caſk, into which the gas is conducted from the intermediate bottle, K, by means of the tube of communication, M, which leads quite to the bottom of the caſk, and is there bent horizontally along the bottom, ſo that the gas may come out under the loweſt of the three reverſed buckets or receivers, expreſſed in the perpendicular ſection of the caſk, at Fig. 3. O, is a handle, or winch, by which the agitator, to be afterwards deſcribed, is ſet in motion, on purpoſe to promote the combination of the gas with the water in the caſk. P, is a foſſet and ſpigot, for drawing off the oxygenated liquor when its preparation is completed.

Fig. 2. Is a plan, or repreſentation, of the upper part of the liquor caſk. Q R S T, are four ſtaves, conſiderably thicker than the others of which the caſk is compoſed, and which project on the inſide, where they receive the extremities of two bars of wood, U V, which ſupport the bottom of the reverſed buckets, or receivers of gas, X.

Each of the three buckets, as repreſented in the ſection, Fig. 3. are ſupported by two ſimilar bars, fixed into the thick ſtaves.

Fig. 3. Is a repreſentation of the liquor caſk cut in two, perpendicularly, on purpoſe to ſhow the diſpoſition of its interior apparatus. Each bucket, X, is conſtructed and placed in ſuch a manner as to receive the gas, in proportion as it eſcapes through the communicating tube, M, at y. The gas, in the firſt place, forms a ſtratum below the undermoſt bucket, which increaſes till that is filled, diſplacing the water, which riſes to the upper part of the caſk. When the undermoſt bucket is filled, the additional gas eſcapes through the funnel, Z, into the middle

bucket; and, when that is filled, it paſſes through a ſimilar opening into the upper bucket. In the center of each bucket there is an opening formed, in the manner of a funnel, through which the ſtaff, E, of the agitator paſſes, but ſo as to prevent the eſcape of the gas from the buckets by theſe openings. This ſtaff has three tranſverſe branches or arms, P, which are ſecurely fixed to it by a wedge, at q. By means of theſe arms the water is agitated, to facilitate the abſorption of the gas, by turning it backwards and forwards with the winch or handle, O, Fig. 1. One of the branches of the agitator is repreſented horizontally, in a ſeparate figure, at r s.

The bent tube, TV, ſerves for drawing out the air from the reverſed buckets, after the caſk has been filled with water. For this purpoſe, the bent part of the tube is introduced below each bucket ſucceſſively, as is ſeen in the plate, at T. We muſt then blow forcibly through the tube with the mouth, ſo as to drive out any water that may have got into it while it was paſſing through the water; and, after this has been done, the air will readily eſcape through the tube, in conſequence of the preſſure of the ſuperincumbent water. This eaſy operation muſt be done ſucceſſively with each bucket, when it is judged that all the atmoſpherical air has been driven out of the diſtilling apparatus, and tubes of communication, by the oxygenated muriatic acid gas. This circumſtance is readily aſcertained, by obſerving the colour of the gas in the tube which communicates between the intermediate bottle and the caſk.

Fig. 4. Repreſents Woulfe's apparatus for diſtilling common muriatic acid, and other very volatile ſubſtances, as farther improved by Mr Welter *. A, is a retort, which is placed in a reverberatory furnace, or ſand heat. Its mouth is ſecured by means of a cork, B, having two holes; through one of theſe is introduced the bent tube,

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* This apparatus will anſwer extremely well for preparing the oxygenated muriatic acid, or the oxygenated alkaline liquor, in ſmall quantities, for the purpoſe of experiment.—T.

tube, DE, the ſuperior extremity of which is formed into a funnel, F, through which the acid uſed in the proceſs is gradually introduced into the retort. The other hole in the cork receives the extremity of a tube, G, which communicates with the jar, H, which has about an eighth part of its capacity filled with water. This jar may either be made with three necks, as the intermediate jar in Fig. 1. or with one large mouth, filled by a cork * pierced with three holes, as in Fig. 5. Through one of theſe holes the

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* The corks uſed in this apparatus, or in any one wherein corroſive acid vapours are produced, ought to be prepared by boiling in a mixture of bees wax and roſin, in the manner deſcribed in Lavoiſiers Elements of Chemiſtry.—T.

the tube, G, paſſes, which communicates between the retort and this jar; through the ſecond, the ſecurity tube, K, is introduced to the bottom of the water, and ſerves to prevent the bad conſequences which might be produced by reabſorption, or ſudden refrigeration; and through the third, paſſes the tube, N, which communicates with the ſecond jar, P. This ſecond jar is half filled with water, and communicates with a third jar, Q, which is provided with a ſecurity tube, R; and the third jar communicates with a fourth, T. According to the nature of the proceſs, the number of theſe jars may be increaſed or diminiſhed, taking care always to have a ſecurity tube in each alternate jar; and, if intended for experiments of reſearch, for determining the component ingredients of bodies, which contain gaſſes of a permanently elaſtic, or very difficultly condenſible, nature, the laſt jar ſhould have a tube, ſimilar to the one repreſented in the plate, at S, which communicates with a pneumato-chemical apparatus *.

At Fig. 5. is repreſented an intermediate jar, k, into which, by means of one large opening, and a cork pierced with three holes, the proper tubes, h l m, are inſerted, ſo as to anſwer equally with the three necked jar, repreſented

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* For more extended inſtructions on the method of conducting chemical experiments, Lavoiſiers Elements of Chemiſtry may be conſulted.—T.

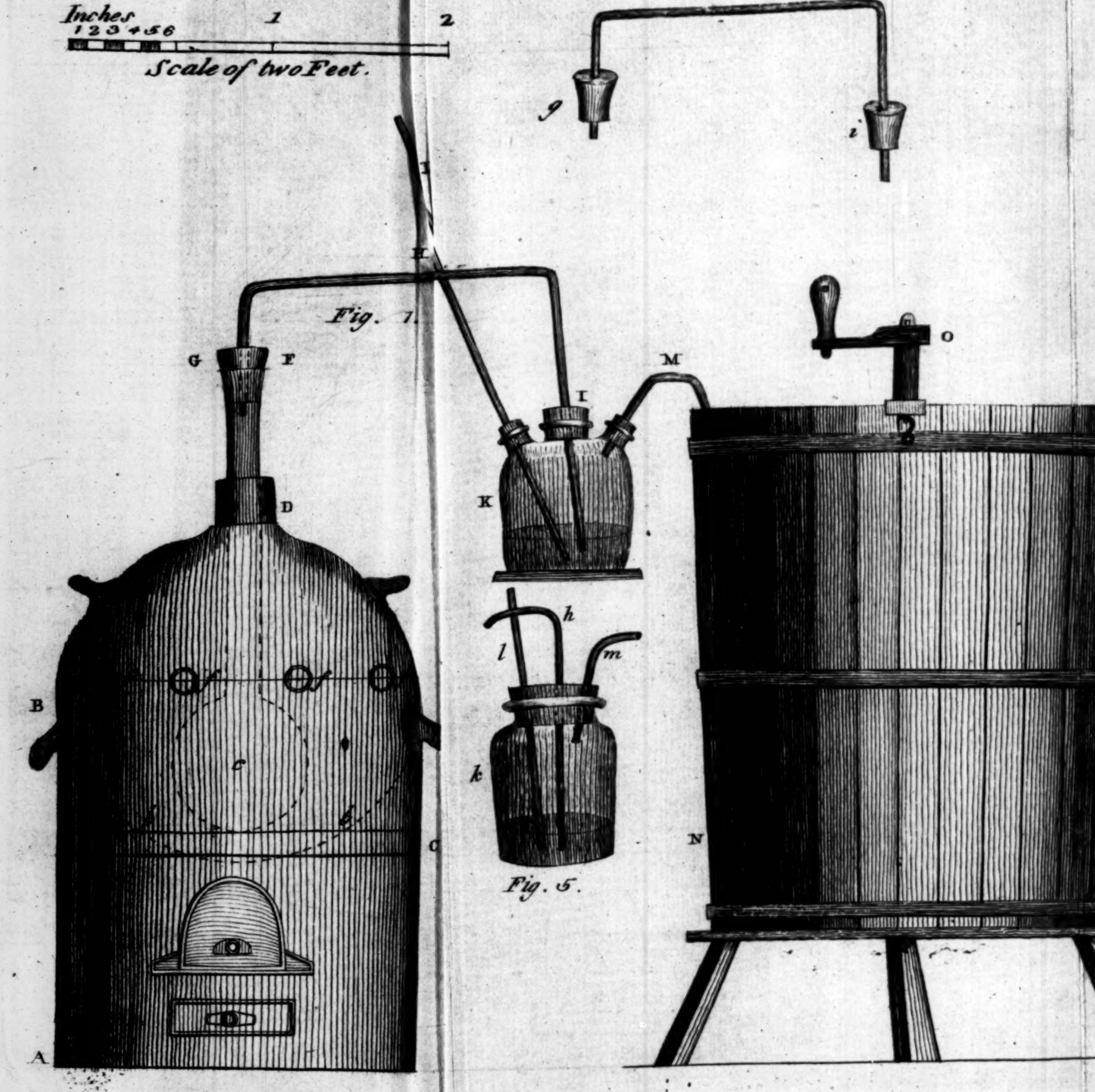
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Fig. 1.

Fig. 5.

Fig. 4.

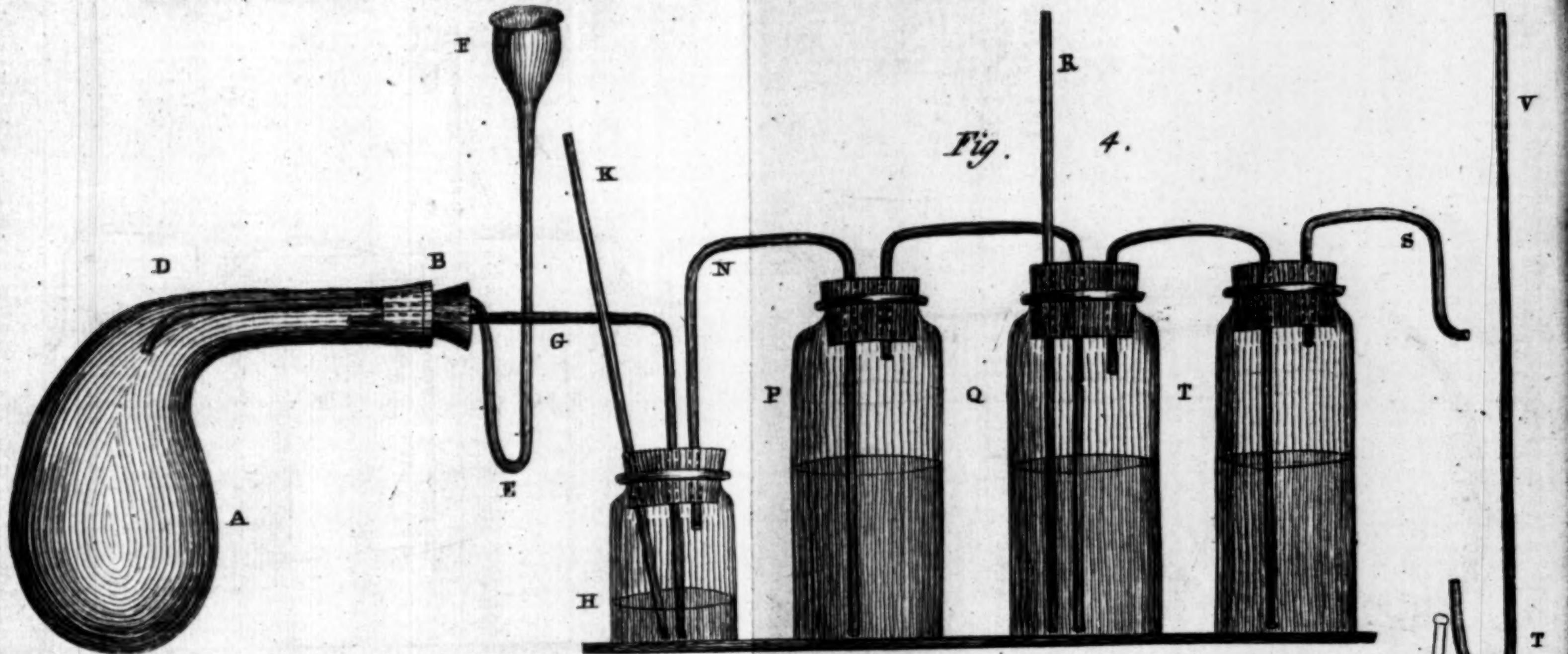


Fig. 2.

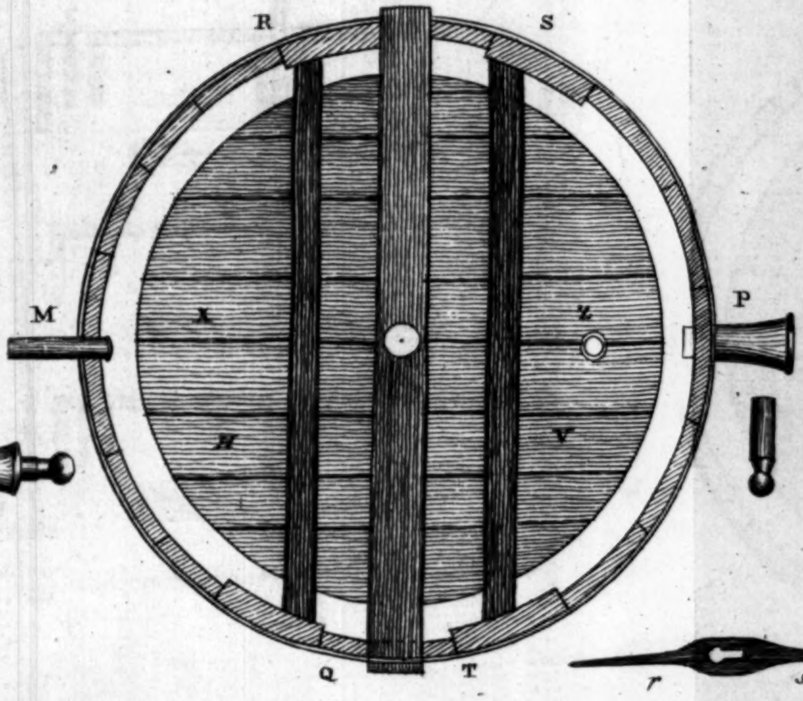
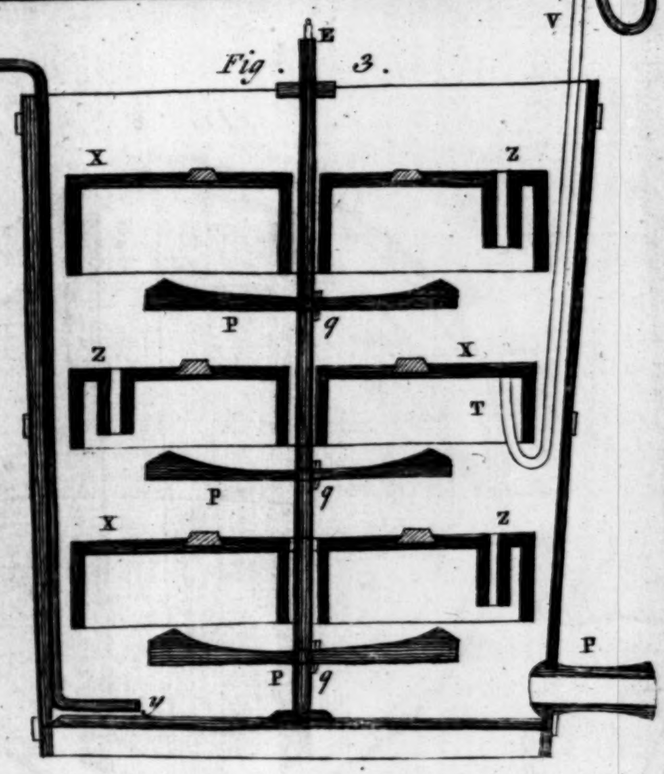


Fig. 3.



BRITISH MUSEUM

preſented at Fig. 1. By this means, the three necked jars, which are ſometimes difficultly procurable, may be diſpenſed with.

OBSERVATIONS AND EXPERIMENTS

ON THE

ART OF DYING

WITH

MADDER.

OBSERVATIONS

ON

DYING WITH MADDER.

SECT. I.

INRTODUCTION.

MADDER is a drug of the higheſt importance in the dying art; but extremely tedious and complicated proceſſes are neceſſary for fixing, and giving an agreeable ſhade, to the colour which it communicates to cotton and linen goods. This is more eſpecially the caſe with the proceſs for producing the Turkiſh or Adrianople red, which has been long, and ſucceſsfully, practiſed in Normandy, and ſeveral other parts of France.

To collect and arrange the various obſervations and experiments which have been made to diſcover the beſt methods for giving beauty and permanency to the colours produced by means of madder, eſpecially upon cotton, and cotton goods, ſeemed to me an object of conſiderable importance to the manufacturing intereſt. By ſuch a collection the manufacturers may be enabled to correct, and ſimplify the proceſſes which they at preſent employ; and may be directed in the proper methods of endeavouring to improve by new experiments.

When a perſon is ignorant of what has been already done, with a view to improvement in any particular ſubject connected with the arts, he may commit numerous and expenſive blunders in his endeavours to improve any of its proceſſes; while, on the contrary, theſe might eaſily be avoided, and the deſired improvements much more readily deviſed, if the ſucceſsful and abortive attempts, which have been already made on the ſame ſubject, were faithfully and regularly reported, from time to time, in publications ſimilar to the preſent.

The chief purpoſe of the following collection, is to relate and explain the various circumſtances which may influence the goodneſs or imperfection of colours produced by madder, according to the various proceſſes in uſe at preſent. It will likewiſe be found to point out ſeveral new methods of proceeding; and to indicate the moſt proper means of attempting improvements in this branch of dying.

As my principal object was to ſelect ſuch experiments as might contribute to improve the dying art, I requeſted Mr Watt, who is much converſant in moſt of the uſeful arts, to favour me with any obſervations that might have occurred to him on the ſubject. In conſequence of this application, the analyſis of madder, which forms the next ſection of this Eſſay, was ſent me by that excellent chemiſt.

The next part conſiſts of a number of experiments by Mr Vogler, extracted, at my deſire, by Mr Welter, from a Memoir in Crells Neuſte Entdeckungen, vol. xiii. Theſe are followed by an abridgement of a Memoir by Mr Gren, in vol. viii. of the ſame publication, in which the principal conditions neceſſary for preparing the true Turkiſh or Adrianople red, are aſcertained; and the whole is concluded by ſeveral experiments, made by myſelf, partly in conjunction with Mr Welter, with the view of rendering the preceding obſervations more generally uſeful to the manufacturers, intermixed with practical obſervations on the ſubject.

SECT. II.

Obſervations on the Properties of the beſt Zeland Madder, by Mr Watt.

1. THIS madder is imported in the ſtate of a coarſe, and ſomewhat coherent, browniſh orange coloured powder. It attracts humidity from the atmoſphere, and thereby loſes its properties, ſo as to be no longer fit for dying.

2. With water it gives an orange coloured infuſion, verging towards brown, and requires a conſiderable proportion of water to extract the whole.

whole of its colouring matter. Margraff directs three quarts of water to be uſed for two ounces of madder. Water extracts the colouring matter, either when hot or cold, but it ſeems to yield a more beautiful colour to cold than to hot water, the decoction being browner than the cold infuſion.

3. When the infuſion or decoction are ſlowly evaporated, in an open veſſel, a pelicle forms on the ſurface of the liquor. This, after ſome time, falls to the bottom of the evaporating veſſel, and is ſucceeded by a ſecond pelicle, which ſubſides in the ſame manner, and ſo on in ſucceſſion, till the whole fluid be evaporated.

4. The extract of madder, which remains after this evaporation, is of a dark brown colour, and is only, in part, ſoluble in water, to which it communicates a light browniſh tinge.

5. If an infuſion of madder be digeſted for ſeveral days, with a moderate heat, in an open veſſel with a long neck, ſo that the aqueous vapours which riſe from the liquor may condenſe, and fall back again, it depoſits dark brown pelicles, which are difficultly ſoluble in water, and leave the liquor of a light brown colour.

6. By means of alum, the infuſion of madder is made to depoſit a dark red lake, or precipitate, in a ſcaly form,

while the ſupernatant liquor retains a yellow colour, verging towards brown.

7. From this remaining liquor, (6.), the alkaline carbonats, or mild alkalies, precipitate a blood red lake of greater or leſſer intenſity of colour, in proportion to the quantity of alum contained by the infuſion.

In this way a lake for painting may be prepared; but there are no means hitherto known of giving equal brilliancy with that which is made from cocheneal. It is tranſparent when mixed with oil, but, when mixed with water, is dull and opake.

8. If too large a quantity of alkali be employed in the preparation of this

precipitate, (7.), the lake is rediſſolved, and the liquor becomes red.

9. This precipitate, (7.), when prepared with carbonat of ſoda, or mild mineral fixed alkali, is not of ſo fine a colour as when the carbonat of potaſh, or mild vegetable fixed alkali, is employed.

10. Calcareous earth, eſpecially in form of lime water, gives a darker and browner coloured precipitate than thoſe produced by the alkalies.

11. When a few drops of alkaline liquor, or aqueous ſolution of one of the fixed alkalies, is added to the water with which the infuſion, (2.), is prepared, conſiderably more of the colouring

ing matter is extracted, and the infuſion becomes of a deep browniſh red colour.

12. From this infuſion, (11), a dark brown lake is precipitated, by means of alum.

13. When any acid is added to it, in a ſmall quantity, it becomes yellowiſh; and, if the quantity of acid be increaſed, the colour changes to a browniſh yellow; but there is no precipitation in either caſe.

14. When the infuſion, (11.), is evaporated to dryneſs, a gummy extract remains, which is readily ſoluble in water.

15. If the infuſion, (2.), is made in water ſlightly impregnated with a mineral acid, it is of a yellowiſh colour. If the digeſtion be continued for a conſiderable time, the liquor acquires a greeniſh brown colour, and the original red ſeems deſtroyed. But the red may again be recovered by the addition of an alkali; after which, by evaporation, the infuſion will yield an extract readily ſoluble in water.

16. If ſome carbonat of magneſia, aërated or mild magneſia, is added to the water of infuſion, (2.), the infuſion is of a clear blood red colour; which, by evaporation, gives a dark red extract, eaſily ſoluble in water.

17. If this extract, (16.), is diſſolved in water, and uſed as a red ink, it becomes yellow by expoſure to the ſun.

18. From this infuſion, (16.), a precipitate of a bad colour is thrown down by the addition of alum.

19. When this lake, (18.), is precipitated by means of alkalies, it acquires a redder, and more fixed colour.

20. If ſome alum be diſſolved in the water of infuſion, (2.), it is of an orange yellow colour.

21. By means of an alkali, a lake, ſimilar to that deſcribed at (6.), but of a worſe colour, may be precipitated.

22. If ſome ſolution of acetite of lead, ſaccharum ſaturni, be added to the infuſion, (2.), it throws down a browniſh red precipitate.

23. From the ſame infuſion, (2.), a ſolution of mercury in nitric acid, gives a purpliſh brown precipitate.

24. A ſolution of ſulphat of iron, coperas, or green vitriol, gives a clear brown precipitate.

25. Sulphat of zinc, white vitriol, has not been tried.

26. Sulphat of mangaueſe gives a precipitate of a purpliſh brown colour.

27. The nitro-muriat, and ſulphat of tin, or tin diſſolved in aqua regia and in ſulphuric acid, have not been tried.

28. The preparation uſed by calico printers, which will afterwards be deſcribed, gives a beautiful browniſh red precipitate.

29. When the infuſion, (2.) is mixed quite hot with an infuſion of cochineal, a browniſh red precipitate, verging towards dark purple, is formed. By continuing the digeſtion, the quantity of this precipitate, which is difficultly ſoluble in water, is conſiderably increaſed.

30. When a piece of cloth, which has been ſteeped in calico printers liquor,

quor, (28.), is dyed in the mixed infuſion, (29.), it acquires a browniſh red colour, which, after boiling in ſoap and water, becomes tollerably good.

31. The ſoap water uſed in this operation, (30.), becomes very red; but paper is ſtained by it only of a very indifferent colour.

SECT.

SECT. III.

Experiments by Mr Vogler, on the Art of Dying Thread and Cotton by means of Madder.

1. BY madder, in commerce, is underſtood the dried and pounded root of the rubia tinctorum, *Lin.* The freſheſt, and beſt prepared, is of an orange colour, and ſtrong diſagreeable odour, ſimilar to that of opium. Both of theſe diſappear by keeping, and the madder becomes of a dark brown colour, but without loſing any of its virtues, ſo far as relates to dying.

2. Madder gives a red colour to cotton and thread, which powerfully reſiſts the action of the ſun and air; being, in this reſpect, greatly ſuperior to the reds produced by means of Braſil wood, cocheneal, or carthamum. It is not enough, however, that a good colour ſhould ſtand the action of the air; it ought likewiſe to reſiſt the repeated actions of alkaline lixivia, alum, ſoap, and acids; more eſpecially the effects of aqua fortis, or dilute nitric acid. Such is the colour of the true Adrianople red cotton, or Turkiſh red. Madder is uſed for dying in many parts of Germany; but none of the ſpecimens which were ſent me from any of theſe places had any conſiderable fixity.

3. It muſt be acknowledged, that the beſt fixed madder colour, even the Turkiſh, is weakened, and at laſt deſtroyed, by means of ſoap. The only difference between the true and falſe Turkiſh reds, in this reſpect, being, that the former reſiſts much longer than the latter; hence, as little ſoap as poſſible muſt be uſed in waſhing linen or cotton goods which are dyed with this colour.

4. Aqua fortis, or dilute nitric acid, is the beſt and readieſt teſt for diſtinguiſhing between the true and falſe dyed Turkiſh reds. If a thread of the latter be immerſed in that acid, it quickly grows pale, and becomes entirely whitened in leſs than a quarter of an hour. A thread of the true Turkiſh

dye, on the contrary, will reſiſt a full hour without alteration, and does not loſe its colour altogether in any length of time, being only changed to orange by long immerſion.

5. I have no manner of doubt that the Turkiſh cotton is dyed by means of madder, for the following reaſons. By the action of alkaline leys, aqua fortis, ſolution of blue vitriol, &c. it ſuffers exactly the ſame alterations that thread and cotton underwent which I had dyed by means of madder, only that the former ſhowed conſiderably more fixity. I have even ſhaken out ſmall fragments of madder from Turkiſh cotton. To judge from the appearance of theſe fragments, I am inclined to believe, that the Turks do not dry

and grind their madder before uſing it, as is done with us, but ſimply bruiſe it in its freſh ſtate.

6. I mean to give a detailed account of the experiments I have made, with the view of improving and perfecting the art of dying with madder. It is well known that cotton and linen do not take on moſt colours unleſs previouſly impregnated with ſome fixing liquor, or without being already dyed of ſome other colour which may ſerve as a ground: I ſhall therefore treat, in the firſt place, of fixing liquors, and ſhall afterwards give an account of the manner of preparing madder vats, or decoctions for dying.

7. I ſteeped ſome thread and ſome cotton, previouſly well waſhed, for half a day, in a ſolution of three drams of alum in fourteen ounces of water; they were then taken out, and carefully waſhed three or four times in clean water, and afterwards dried in the ſhade. It is more expeditious, and anſwers equally well, to boil the ſubſtances in the alum water for a few minutes, only taking care that all the alum be diſſolved before the ſtuffs are put into it.

Linen and cotton yarn, prepared as above, being boiled during half a quarter of an hour, or a little longer, in the different madder vats, (79. to 95.), acquired a ſcarlet red, not very full, but which might ſerve extremely well as a ground for that colour.

In theſe, and all my other experiments, I have found that Roman alum gives conſiderably more luſtre to the colours than common alum, and, of courſe, the former ought always to be employed.

8. I have always uſed thread and cotton of a yellowiſh colour in my experiments. Theſe were firſt ſteeped for ſome time in an alkaline lixivium, afterwards carefully waſhed in pure water, and then dried. By theſe precautions they became more completely penetrable by the preparing liquor, and more fit, in every reſpect, for the operations of dying.

9. I have never been able to produce a good colour in cotton or linen yarn

by means of the preparation liquor, (7.), with one madder vat. I have made ſeveral other attempts, and ſhall now relate the moſt remarkable of theſe, both ſuch as were ſucceſsful, and ſuch as failed.

10. I have ſometimes repeated the aluming or preparation, (7.), three or four times with the ſame piece of goods, and have even uſed a triple proportion of alum to the quantity of water there directed, but always without ſucceſs. From theſe trials, however, I aſcertained, that the beſt proportions for the preparation were three drams of alum to thirteen or fourteen ounces of water.

11. The addition of cream of tartar, acidulous tartarite of potaſh, or of any

other acid to the preparation, (7.), was always hurtful, even in the ſmalleſt doſe. Such pieces as had been impregnated with the preparation in this manner, always took on a paler colour from the madder vats than in any of my other experiments.

12. When from half to a whole dram of white arſenic, was diſſolved, by boiling, in the preparation, (7.), the effects were neither better nor worſe than when the preparation only contained alum.

13. When ſheep or cow dung, or album grecum, the white dung of dogs, were added to the preparation, (7.), or when urine was ſubſtituted in place of water for diſſolving the alum, the colour was ſomewhat ſtrengthened, but in

ſo inconſiderable a degree as not to appear worthy of notice.

14. By the addition of three or four drams of ſea ſalt, muriat of ſoda, or one dram of ſal ammoniac, muriat of ammoniac, to the preparation, (7.), greater effects were produced than from the articles mentioned in (13.); but, in general, theſe ſalts rendered the colours dull, and without brilliancy.

The addition of ſalt to the preparation, (7.), when uſed for goods that have already received a ground of colour, is of great advantage, as I have experienced that the ſalt powerfully defends the firſt, or ground colour, from the ſolvent power of the alum in ſubſequent preparations.

15. Nearly the ſame effects are produced by the uſe of lime water. After ſteeping in the preparation, (7.), I ſteeped ſome pieces in lime water, and, having wrung and dried them, I a ſecond time ſteeped them in the preparation, (7.), but without any more effect than already related.

16. The ſubſtances from which I have derived greateſt advantage are gum arabic, ſtarch, fenugrec ſeeds, and eſpecially glue. When any of theſe were added to the preparation, (7.), I have uniformly found that the cotton or linen took on a much better and fuller colour from the madder vat. I ſhall give the compoſition of ſeveral preparation liquors in which theſe materials were employed.

17. *Starch preparation liquor.*

Break down two drams of ſtarch in two ounces of water, then add fourteen or fifteen ounces of water, and bring the whole to boil; afterwards, throw in three drams of powdered alum, and diſſolve it thoroughly.

18. *Gum arabic preparation liquor.*

This conſiſts of three drams of gum arabic, and as much alum, diſſolved in fourteen or fifteen ounces of water.

19. *Fenugrec preparation liquor.*

Three drams of bruiſed fenugrec ſeeds are boiled in ſixteen ounces of water, till ſome ounces of the decoction are evaporated, then three drams of alum are diſſolved in the liquor, and the whole is filtered through a fine cloth.

20. *Glue preparation liquor.*

From a dram and half to four drams of fine clear glue, are diſſolved in two or three ounces of water, and added to fourteen ounces of boiling water, in which three drams of alum are diſſolved.

21. I have tried, but without ſucceſs, to impregnate the goods with various greaſy ſubſtances, ſuch as fiſh oil, lard and olive oil; but have always found, that, unleſs ſpecial care was taken to eradicate theſe matters completely, by

means of alkaline leys and ſoap, the goods never could be perfectly impregnated, either with the preparation or the dye.

22. On the contrary, ſtarch, gum, fenugrec ſeeds, and more eſpecially glue, deſerve every attention from the dyer. Nothing, that I have tried, is ſo proper for giving animal properties to flax and cotton. By it they are brought near to the nature of ſilk or wool, and are thereby rendered greatly more fitted for taking on colours of all kinds.

23. The ſolution of glue, without any addition, has a ſurpriſing effect as a preparation liquor. Linen or cotton yarn which have been ſoaked in it, of the proportions directed at (20.), but with-

out alum, and afterwards wrung and dried, take on colour very abundantly from a madder vat, and even bear tollerably well the teſt of nitric acid. From this circumſtance I learned, that we might advantageouſly ſoke the ſubſtances to be dyed in alum water, (7.), and in glue water, inſtead of employing the preparation liquor, (20.), in which both are confounded together.

24. The gaſtric juice of animals, and the ſerum of blood, act preciſely in the ſame manner with glue. To procure ſerum, I allowed the blood to coagulate, and ſtrained it through a cullender; but glue is more convenient.

25. Such cotton or linen yarn as have only received the preparation from ſerum

or glue, take a dirty dull red from the madder vat. This colour is greatly heightened by alum, whether it be diſſolved in the glue liquor, (20.), or uſed ſeparately.

26. I have never been able to produce a well filled colour, by any of the above deſcribed preparations for diſpoſing the linen and cotton to receive the dye: But I have been enabled to ſucceed by means of a ſolution of earth of alum in the nitric or muriatic acids, by a ſolution of white arſenic with potaſh, by corroſive ſublimate, ſolution of tin, madder itſelf as a preparation, and by means of galls, and all the ſtrong vegetable aſtringents, as will appear from the following experiments.

27. By means of potaſh, I precipitated a quantity of earth of alum, which I waſhed and dried. One portion of this was diſſolved in nitric, and another portion in muriatic, acid. Theſe two ſolutions were ſeparately diluted with two or three times their bulk of water; and in each ſome linen and cotton were ſteeped during one night, after which they were well waſhed and dried. After preparation in this manner, they were dyed in a madder vat, and acquired a very full and brilliant ſcarlet. The ſtuff which had received the preparation in muriat of argil, ſolution of earth of alum in muriatic acid, was very well ſaturated with colour, but not ſo brilliant as that which was prepared by the nitric ſolution. Both theſe colours bore the teſt of nitric acid con-

ſiderably better than any of thoſe produced by the preceding proceſſes.

28. I am convinced, from numberleſs experiments, that muriatic acid, and all the muriatic ſalts, have the quality of rendering all colours more ſaturated or fuller, but more dull at the ſame time, whether they be uſed with wool, ſilk, linen, or cotton. (See 14. 27. 31. 38. 42. 43. 44 45. 59. 65. 70. 83. 87. 88. and 94.).

29. The advantages poſſeſſed by the nitric and muriatic ſolutions of earth of alum, nitrat and muriat of argil, as preparations for dying, over alum water, (7.), whether common or Roman, conſiſt not only in penetrating the ſtuffs more perfectly, and thereby producing more

full and more durable colours, but theſe colours are likewiſe of a more agreeable ſhade, eſpecially when the nitric ſolution is employed.

The above fact occurred to Mr Wentzel, and is taken notice of in the explanation of his doctrine of Affinities, p. 113. 114. and 115.

30. In a ſtrong lixivium of potaſh, I diſſolved as much white arſenic as poſſible by boiling, and diluted the ſolution with twice its bulk of water; having decanted the clear liquor, I poured it into a ſaturated ſolution of alum. The mixture became opake and gelatinous, but without efferveſcence; and, by adding gradually more ſolution of alum in water, it recovered its tranſpa-

rency. See *Crell's Chemical Annals*, *Part* 10. *pag.* 291. *anno* 1784.

Linen or cotton, ſteeped twelve hours in this preparation liquor, and afterwards waſhed and dried, receive a perfectly ſaturated and beautiful red colour from a madder vat.

31. In fifteen or ſixteen ounces of water were diſſolved, by boiling, three drams of alum and half a dram of corroſive muriat of mercury, or corroſive ſublimate, previouſly reduced to fine powder. Some linen and cotton yarn were ſteeped ſix hours in this preparation liquor, and afterwards waſhed and dried. Theſe received a deep and well filled red colour from the madder vat.

32. Some pure Engliſh tin was diſſolved in concentrated nitric acid, and the ſolution was diluted with twice its bulk of a ſolution of ſea ſalt. Some linen and cotton yarn being ſteeped in this liquor for ſix hours, were taken out, dried, and ſubmitted to the madder vat. They were thereby dyed of a more beautiful, and more ſolid orange red colour, than is produced by dyers from arnotto and alkaline lixivium. It was made ſtill ſtronger by ſteeping for ſome time in the glue preparation, (20.), after taking the ſtuff out of this mercurial preparation liquor, and before drying.

By means of this mercurial preparation, a very agreeable yellowiſh brown colour can be procured from madder of little value. The above orange and yellowiſh brown colours may be changed to an elegant ſcarlet by ſteeping in the alum and ſalt preparation liquor, (14.), and dying a ſecond time in the madder vat. This colour will bear being compared to the moſt beautiful of thoſe produced from Brazil wood or cocheneal.

33. Some linen and cotton yarn, previouſly prepared according to the proceſs in the preceding ſection, were ſteeped in lime water, and then wrung and dried. After this, one portion was ſteeped in the glue liquor, (20.), and the other in the preparation liquor of alum and corroſive muriat of mercury, (31.), and then both were dyed in the madder vat as uſual. Both portions

received a beautiful and deep vermilion colour; but that which had been prepared in the mercurial liquor was duller and more full.

34. Three drams of madder, and the ſame quantity of potaſh, were macerated for a night in fifteen or ſixteen ounces of water, and boiled together for ſome time next morning. Some linen and cotton yarn were boiled in this preparation liquor for eight or ten minutes, and then waſhed and dried. By this preparation they received a weak reddiſh tinge. They were then ſteeped in the alum and ſalt liquor, (14.), next in the glue liquor, (20.), and, laſtly, dyed in one of the madder vats, (79. 83. &c.); and by this proceſs I produced a beautiful and well filled red.

35. If to the madder and potaſh preparation liquor, (34.), ſome arnotto be added, the ſtuffs receive from it a beautiful orange colour, but not of ſo much fixity as the one deſcribed in (32.). The dyers produce this colour in this way in ſeveral places, uſing a ley of wood aſhes inſtead of potaſh.

36. Three drams of madder, and as much Roman alum, were macerated twenty-four hours in ſixteen ounces of water, and afterwards boiled for ſome time. In this liquor, ſome linen and cotton yarn were boiled for ten minutes, rinced and dried, having acquired a pale colour, but more lively than that produced by the liquor in (34.). They were impregnated with the glue liquor, (23.), and then dyed in the madder

vat, (79. 83. 88.), by which the pale colour was changed to a beautiful well filled red.

37. Three drams of madder were macerated during twenty-four hours in ſixteen or eighteen ounces of water, and then boiled for a quarter of an hour. In this, as a preparation liquor, ſome cotton and linen yarn were ſteeped for ten minutes; one portion having been previouſly impregnated with alum liquor, (7.), and the other portion in alum and glue liquor, (20.). After rincing and drying, both portions were impregnated with the alum and ſalt liquor, (14.), and again ſteeped in the ſimple glue liquor, (23.). They were then dyed in the madder vats, (79. to 95.). By this proceſs, the pale

red, which the ſtuffs had received from the weak madder liquor of this ſection, was changed to a beautiful brilliant and well filled red, reſembling the beſt Turkiſh dye. The colour produced in the above manner was ſuperior to thoſe of the ſeveral proceſſes in (34. 36. 39. and as far as 48.).

38. The colours produced by the double maddering proceſſes, (34. 36. and 37.), were all of them weakened, and rendered paler and yellowiſh, by the action of nitric, ſulphuric, and muriatic acids, diluted with two parts of water. The nitric acid was moſt powerful in its effects, the ſulphuric acid leſs ſo, and the muriatic leaſt of all; but this laſt rendered the colours browniſh, and gave them a dirty

hue. Vinegar and tartar have a much weaker action on the colours than any of the three mineral acids. Alum liquor has a powerful effect in diſſolving the colour, but, at the ſame time, renders it clearer, and more brilliant. Potaſh and lime water extract a good deal of the colour, and changes what remains to a deep red.

39. Some cotton and linen yarn were boiled in the madder preparation, (37.), having been previouſly cleaned as in (8.), and one portion impregnated with glue liquor, (23.), and the other with ſerum. The colour produced in this manner was pretty ſtrong, and capable of reſiſting the teſt of nitric acid, but of a dirty hue. The ſtuffs were afterwards prepared in the alum and ſalt li-

quor, (14.), and dyed in a madder vat, by which they acquired a very full and brilliant red colour.

40. Half an ounce of madder, and as much nitric acid, being infuſed for one night, one half of the mixture was diluted with three or four ounces of water, and the other half with an equal quantity of glue liquor, (23.). In each of theſe, ſome cotton and linen were ſteeped for ſix hours, then waſhed and dried. They were afterwards impregnated with the alum and ſalt liquor, (14.), and then dyed in a madder vat, from which they received a beautiful and well filled colour. The above proceſs may be tried with ſulphuric and muriatic acids, inſtead of the nitric.

41. Three drams of powdered galls, of the ſmall black kind, were infuſed, for twenty four hours, in ſixteen or eighteen ounces of water, and afterwards boiled for ten minutes. In this liquor, ſome cotton and linen yarn were boiled for eight minutes, having been previouſly prepared, partly in glue liquor, (23.), and the other part in ſerum, (24.): They were after this rinced and dried, and were found to have received a full colour between grey and brown.

42. Some linen and cotton, ſimply cleaned, (8.), were prepared in the gall liquor, (41.), with the addition of from four to ſix drams of ſalt. The colour produced in this manner was a grey, without any mixture of brown. When

a dram, or a dram and a half, of muriat of ammoniac, ſal ammoniac, was ſubſtituted inſtead of common ſalt, the colour was fuller.

43. Some linen and cotton yarn, previouſly prepared in alum liquor, (7.), were boiled in the gall liquor, (41. and 42.), and acquired a greeniſh grey colour. The portion which was dyed in the gall and ſalt liquor, (42.), was evidently more charged with colour than the other.

44. When the ſtuffs had been previouſly prepared with alum and glue liquor, (20.), they received a very full colour of grey, mixed with green, from the gall liquor, (41.), and ſtill ſtronger

from the liquor of galls, (42.), with the addition of ſalt.

45. When, after impregnation with glue liquor, (23.), or ſerum, (24.), they were boiled in the liquor of galls and ſalt, (42.), the colour was perfectly full, and of a brown grey.

46. Three drams of alum, and as much powdered galls, were infuſed for one night in fifteen ounces of boiling water, and then boiled for a few minutes. In this liquor ſome cotton and linen yarn were boiled for eight minutes, and acquired a beautiful greeniſh grey colour, but leſs full than thoſe produced by the preceding proceſs with galls. When the alum was reſerved till the infuſion of galls was made to

boil, I found it to anſwer better than when added to the galls at the beginning.

47. When I ſubſtituted potaſh in place of the alum, in the preceding proceſs, the colour produced was a brown grey, and not ſtronger than in the former proceſs, (46.).

48. Cotton and linen yarn are diſpoſed for taking on the madder dye by means of previous preparation in gall liquor. Such ſtuffs as have been impregnated with any of the gall preparations (from 41. to 47. incluſive), then ſteeped in alum and ſalt liquor, (14.), and afterwards dyed in one of the madder vats, (from 79. to 95. incluſive), acquire a perfectly ſaturated red colour;

but rather of a dulliſh hue. I prefer the gall preparation liquors, (41. 42. 43. 44. and 45.), to the others.

49. When the linen and cotton yarn have been prepared in ſolution of tin, (32.), and afterwards in glue liquor, (23.), they take from the gall liquor, (41. or 42.), a rich yellowiſh grey colour. By the ſame proceſs, ſimilar colours may be produced from the other vegetable aſtringents, (52.).

50. Half a dram of cocheneal, in fine powder, were infuſed a whole day in thirty-two ounces of boiling water; in the evening, five drams of finely powdered galls were added, and the whole was boiled for ſome minutes next morning. Some linen and cotton yarn, pre-

viouſly prepared in ſolution of tin, (32.), and then in glue liquor, (23.), were boiled for ten minutes in the above liquor, and being rinced and dried, were found to have received a well filled and clear red, a little dirtyiſh in its hue.

51. Some yarn, previouſly prepared according to the proceſſes in (49. and 50.), were impregnated with alum and ſalt liquor, (14.), and then dyed in a madder vat. Both parcels, but chiefly the one prepared with cocheneal liquor, (50.), acquired an uncommonly beautiful well filled and brilliant colour of conſiderable fixity.

When the alum and mercurial liquor, (31.), was uſed in the above proceſs, in place of alum and ſalt liquor, (14.), the colour was ſomewhat fuller.

52. Several other vegetable aſtringents anſwered equally with gall nuts; among others, the bruiſed barks of alder, and of oak, and of the roots of hazel; the dried flowers and bark of pomgrenates; the leaves, tops, and bark of ſumach. Of theſe the colour produced from oak bark has always reſiſted the teſt of nitric acid better than the others.

53. Having given an account of my experiments for aſcertaining the beſt preparation liquors for dying cotton and linen of a fine red colour, by which it appears that alum, both Roman and roch, but chiefly the former, and the tin ſolution, are beſt

adapted for the purpoſe, I ſhall now relate my experiments with other ſalts, both of metallic and earthy baſes, tho' they appear to be little fitted for dying red. From moſt of them I have produced other colours; but as theſe may have their uſe in dying, they are perhaps not unworthy of being mentioned.

54. Some cotton and linen yarn were ſteeped five or ſix hours in ſolution of ſilver by nitric acid, diluted with five parts of diſtilled water. After rincing and drying, they were dyed in a madder vat, but the colour was very bad, having more of a grey than of a red ſhade.

55. When managed in a ſimilar manner with a diluted nitric ſolution of

lead, they received from the madder vat a full, but dirty, brown red.

56. Uſing litharge, or ſemivitrified oxyd of lead, inſtead of metallic lead, for the nitric ſolution, made no change in the reſult of the experiment.

57. All the ſolutions of lead, which I have tried, when uſed as preparations for cotton and linen, diſpoſe them to receive abundantly the colouring matters of vegetable dyes, but always give them a dirty and dark appearance. Theſe may however be advantageouſly employed as preparations for brown and black colours. For inſtance, when the bad colours, produced in the proceſſes, (55. and 56.), are prepared with alum and ſalt liquor, (14.), and then dyed a

ſecond time in a madder vat, they are changed to a perfect and very beautiful brown. I have likewiſe produced a very beautiful black on cotton and linen, by preparation, in the firſt place, with ſolution of lead, (55. or 56.), then dying with galls, afterwards impregnating with a ſolution of ſulphat of copper, blue vitriol, and, laſtly, boiling them in a decoction of logwood.

58. I tried, as a preparation, mercury diſſolved in nitric acid and diluted with three parts of water, or ſolution of nitre in water. After this, as in the proceſs with lead, the madder vats produced a pretty full, but dirty and dull, red colour. When the ſtuffs, after being taken from the above mercurial preparation liquor, were waſhed in hard

water, they become of a ſulphur yellow colour.

59. A ſolution of corroſive muriat of mercury in fifteen parts of water produced, as a preparation, ſimilar effects with the nitric, (58.), ſolution.

60. A ſolution of native biſmuth in aquafortis being diluted with two parts of a ſolution of common ſalt in water, an effervefcence took place, and ſome white powder, which had remained undiſſolved by the nitric acid, now diſſolved in the mixture. When this was uſed as a preparation, the linen and cotton received an agreeable lilac or peach bloſſom colour from the madder vats.

61. Grey ore of cobalt, *cobaltum galena*, diſſolved in nitric acid and diluted with two parts of ſolution of common ſalt, being employed as a preparation for the madder vats, produced a very full and agreeable violet colour.

62. A ſolution of ſulphat of copper, blue vitriol, employed as a preparation liquor, produced a bad lilac colour.

63. Verdegris, or acetite of copper, diſſolved in vinegar, produced a ſimilar effect.

64. A ſolution of nitrat of copper, or copper diſſolved in nitric acid and diluted with water, uſed as a preparation, produced a colour of the ſame kind with the two preceding preparations,

tions, but greatly more beautiful and better filled.

65. The muriatic ſolution of copper produced a ſimilar effect.

66. The vitriolic ſolutions of iron or of copper, employed as a preparation before the madder vats, produce a dull, and dirty, violet colour.

67. A moderately ſaturated ſolution of ſulphat of copper or of iron, being mixed with the alkaline ſolution of arſenic, (30.), the mixture became milky, attended with effervefcence; but the tranſparency was reſtored by adding ſome more ſolution of the ſulphat. When this was uſed as a preparation, before the madder vats, I

produced a very elegant, and well filled colour, which ſunk deeply into the ſtuffs.

68. A ſolution of iron in vinegar, when uſed as a preparation, acted very nearly in the ſame manner as the ſulphuric ſolution, (66.), of copper.

69. A nitrous ſolution of iron anſwered better as a preparation than either the ſulphuric, (66.) or acetic, (68.) ſolutions, and produced with the madder vat a beautiful and well filled violet colour.

70. The muriatic poſſeſſes the ſame properties with the nitric ſolution of iron.

71. I have only particulariſed two experiments in which the good effects of a mixture of the alkaline ſolution of arſenic, (30.), with the other ſaline preparation liquors, are taken notice of; but I have experienced, that all the earthy and metallic ſalts are changed, by means of the arſenical alkaline ſolution, in ſuch a manner as to be much better adapted, as preparations, for every kind of colour.

72. The alkaline ſolution of arſenic has likewiſe this remarkable property, that all the preparation liquors into which it enters as an ingredient, preſerve their properties, when the ſubſtances which have been impregnated with them happen to be kept a long while, even expoſed to the free action

of the air, before they are dyed. Some cloths have been dyed ſeveral years after receiving the above preparation, and it did not ſeem to have loſt its force in any ſenſible degree; whereas, if a cloth which has been prepared by any other preparation, is left undyed for a fortnight, the effects of the preparation liquor are very viſibly impaired. Some of the preparation liquors, and among others the ſolution of tin, muſt be excepted from this general rule.

73. Sulphuric ſolution of zinc acts in the ſame manner with the ſulphuric ſolution of copper, only that the violet colour is weaker.

74. Nitrous ſolution of lime has no effects worth notice.

75. Sulphuric ſolution of lime is equally inſignificant with the preceding.

76. The effects of ſulphuric ſolution of manganeſe are rather more remarkable. The colour produced by this, and the two preceding ſolutions, is weak, and of a dirty hue.

77. I have regularly adviſed, in all the preceding obſervations, to rince the cotton and linen very carefully, when taken out of the preparation liquor; for, if this precaution be neglected, the ſtuffs will only acquire a weak ſhade of colour from the ſubſequent

quent madder vats; becauſe the ſaline particles of the preparation, mixing through the madder vat, will combine with a conſiderable portion of the colouring matter of the madder, and render theſe incapable of fixing to the fibres of the ſtuffs.

I have diſcovered ſeveral dyes in the indigenous plants of Germany, which I ſhould never have ſuſpected to exiſt, if I had not uſed the above precaution; eſpecially as theſe colouring matters are but in ſmall proportion among the other juices of the plants.

I uſe three or four ſucceſſive waters for the above purpoſe, ſoaking, and ſtrongly expreſſing the ſtuffs ſeveral times with each; and I have never found that the rincing carried off any part of the preparation that is of ſervice to the ſubſequent dying proceſs.

78. We can never ſucceed to produce a good colour by mixing the preparation with the dying vat, unleſs in ſuch dye ſtuffs as abound very much in colouring matter; ſuch are Brazil wood, logwood, yellow wood, turmeric, and ſome others, which are ſo rich in colour, that we hardly perceive the deterioration produced by the addition of the preparation. This mixture is always extremely prejudicial, and diſtinctly perceptible, when the dye ſtuff happens to be rather poor in colouring particles, as may be ſeen in the 36th and 46th paragraphs. From theſe obſervations, I have made it a rule never

to mix the preparation with the vats, even in the richeſt and ſtrongeſt dyes; and I have found great advantage from the precaution.

79. I ſhall now give an account of the various ways in which I prepared my madder vats.

I infuſed three drams of madder in ſixteen or eighteen ounces of rain or river water for twenty-four hours, and then boiled them for ſeven or eight minutes at the moſt. The ſtuffs to be dyed were then plunged into this while boiling, and boiled in it for eight minutes, and then rinced in two or three ſucceſſive quantities of cold water, and dried in the ſhade. Too long boiling in the dye is apt to take away, or diſcharge, part of the colour which has fixed in the ſtuffs; and the ſun's rays very powerfully diſcharge the colours, eſpecially while ſtill wet from the vat or copper.

80. Freſh urine was uſed, inſtead of water, for preparing the madder vat, and the colour was ſomewhat more fixed. This anſwers better in winter than in ſummer; becauſe the urine is apt to corrupt in warm weather, by which circumſtance the vat is rendered perfectly uſeleſs.

81. One dram of ſheeps dung, or of album grecum, or the white dung of a dog, added to the vat, (79.), produces the ſame effects with urine.

82. Brandy, uſed inſtead of water, produced a weak bad colour.

83. I ſometimes added three drams of common ſalt, or one dram of ſal ammoniac, muriat of ammoniac, to the vat, (79.), immediately before the ſtuffs were put in. By this means the colour produced was fuller, entered deeper into the ſubſtance of the ſtuff, and more forcibly reſiſted the teſt of nitric acid; but it was always ſomewhat tarniſhed. Sulphat of potaſh, or vitriolated tartar, and nitre, produced no effect whatever when added to the vat.

84. Three drams of white ſugar, added to the vat, (79.), produced a more beautiful, and better filled colour, which was ſtill farther improved in its

power of reſiſting the action of nitric acid, by adding four drams of long pepper to the vat.

85. One dram, or a dram and half, of ſtarch, or a dram and half of gum arabic, added to the vat when it comes to boil, and immediately before the ſtuffs are put into it, gives a finer, and more ſaturated colour, than when this addition is omitted.

86. Four drams of pulveriſed fenugrec ſeed, added in the ſame manner, produces nearly the ſame effects.

87. When four drams of Spaniſh pepper are added at the beginning of the infuſion, (79.), the colours are more fixed than in any of the preceding

in proceſſes. An addition of three drams of common ſalt ſtill farther improves the fixity of the colours.

88. One ounce, or an ounce and half of ſtrong glue ſize, added to the vat, (79.), at the commencement of the boiling, produced a very beautiful and well filled colour. The addition of three drams of common ſalt, as in the preceding proceſs, both added to the fixity of the colour, and preſerved the vat from corrupting.

89. Four drams of bullocks gall, added to the vat, rendered the colour extremely beautiful, but, at the ſame time, more readily deſtructible by the teſt of nitric acid.

90. All the madder vats which I have deſcribed, excepting thoſe which are prepared with urine, (80.), with glue, (88.), or with the dung of animals, 81.), may be kept a long while without loſing any of their efficacy. I have uſed ſuch as were quite mouldy and ſtinking, and found them to dye extremely well; I even obſerved that the colour was more fixed than with freſh made dye; at leaſt, it more powerfully reſiſted the nitric acid teſt.

91. Juſt before putting in the ſtuffs, I added to the vat, (79.), thirty ſix or forty grains of cream of tartar, which enabled the colours to reſiſt the nitric acid teſt more forcibly.

92. Very ſmall additions of ſulphuric, nitric, or muriatic acids, produce effects ſimilar to thoſe of tartar; but, if the proper proportion be exceeded, the colours are rendered pale, and only half dyed.

93. Half a dram of alum, uſed in the ſame manner, improves and beautifies the colour, but without increaſing its fixity.

94. Twenty four grains of corroſive muriat of mercury, or corroſive ſublimate, rendered the colours ſomewhat leſs brilliant, but of greater fixity.

95. White arſenic, in various proportions, had no effect whatever; tho

it and orpiment are uſed by the dyers with the view of fixing their colours.

96. River or rain water extracts, by cold infuſion, a browniſh red from madder. A ſolution of ſulphat of potaſh, or of nitre, extracts a ſimilar colour, but more clear, and requires a longer time. The ſolution of common ſalt, and of ſal ammoniac, extracts a clear and tranſparent yellow colour. The ſulphuric, muriatic, nitric, and acetous acids, and the ſolution of acedulous tartarite of potaſh, or cream of tartar, added to the infuſion of madder, renders the colour deep yellow. Solution of arſenic acts like pure water. Solution of corroſive ſublimate produces a yellow colour. Solution of alum gives a bright colour, mixed red

and brown. Gall nuts, or any other aſtringent in powder, uſed along with the madder, produces a reddiſh yellow, or orange coloured infuſion. Spirit of wine draws a deep yellow tincture from the madder. A lixivium of potaſh with lime water, extracts a conſiderable quantity of a dark brown red colour.

From theſe experiments, it will be evident why I have not employed ſal ammoniac, common ſalt, tartar, corroſive ſublimate, &c. in the preparation of the vats, from the commencement of infuſion, (50. 83. 91. 92. 93. 94. and 95.), as theſe ſubſtances prevent the diſſolution of the colouring particles.

97. I boiled my madder vats in earthen veſſels, lined with tin or copper, made deep and narrow, for more conveniently containing the ſtuffs to be dyed. At the commencement of ebulition, the vats are very apt to froth up and run over, which muſt be carefully guarded againſt.

98. On purpoſe to prevent the threads of ſuch ſkains of cotton or linen yarn, as were dyed in my experiments, from matting together, the beſt means I could deviſe, was by two bands at the oppoſite extremities of each ſkain.

99. In all my experiments, the thread, yarn, and ſtuffs made of cotton, took on the colours better than thoſe of flax or

of hemp; but, when the latter were a little worn, ſo as to become ſoft to the touch, or were of a lax texture, having their threads but little twiſted, the difference between them and cotton was very ſlight in the above reſpect.

100. Each of the above deſcribed experiments were ſeveral times repeated, ſome as far as ten times. Several of my proceſſes are now carrying on, in the way of trade, with conſiderable ſucceſs; eſpecially thoſe deſcribed at (32. 37. 44. 45. 48. 49. 50. 51.). My colours are in no reſpects inferior to the Adrianople or Turkiſh red, though conſiderably leſs fixed. I am diſpoſed, however, to conſider them as greatly ſuperior to all the falſe Turkiſh reds

which have been ſent me from various places, and which are in many places employed in fabricating various ſtriped ſtuffs of cotton and of linen.

SECT. IV.

Account of Mr Grens Experiments—thoſe by Mr Berthollet and Mr Welter—and Obſervations on the Subject by Mr Berthollet.

1. IN Mr Grens Eſſay on the manner of dying the true Turkiſh red, he does not pretend to have carried the ſubject to its utmoſt perfection; but he hopes that his obſervations may greatly aſſiſt ſuch as deſire to imitate the true Adrianople or Turkiſh red dye.

2. His proceſs is as follows: He took two ounces of cotton thread,

which he ſteeped for fifteen days in fiſh oil, ſtirring it frequently. He then ſqueezed out the oil as much as poſſible, and boiled the cotton for half an hour in a ſolution of two ounces of Spaniſh barilla. Having poured off the milky lixivium, he boiled the cotton for a quarter of an hour in water or urine, and then waſhed it in ſucceſſive waters, till the water came off perfectly clean and tranſparent.

3. In the next place, he boils for ſome time half an ounce of alum, and two drams of ſumach, in a ſufficient quantity of water, and putting the cotton into this decoction, boils it for an hour, frequently ſtirring and turning it. The whole is then allowed to cool; and, at the end of twelve hours, the

cotton is taken out, and dried in the ſhade.

4. Next day the cotton is carefully waſhed in cold water, and plunged wet into a vat compoſed of half an ounce of madder, in which it is gently boiled for ten minutes, ſtirring it inceſſantly. It is allowed to cool in the dye, and is then taken out and dried in the open air.

5. The cotton, after being rinced in cold water, was of a very beautiful red colour, and bore all the teſts to which the true Turkiſh red is ſubjected. It bore being waſhed in ſoap and water without alteration of colour. In waſhing with a cold lixivium of wood aſhes, the colour rather increaſed in

brilliancy. It is not altered by vinegar in a greater degree than is the true Turkiſh red, from which it only differs in having leſs luſtre; which laſt circumſtance Mr Gren attributes either to a difference in the quality of the madder, or to ſome additional colouring ſubſtance being employed in the Adrianople proceſs.

6. The reſult is preciſely the ſame in the above proceſs, whether urine or water be employed for diſſolving the alum and barilla.

7. When an inferior kind of madder is uſed in the above proceſs, the colour produced is a dirty brown, without luſtre or beauty; but the beſt Ze-

land madder gives the fine colour already deſcribed.

8. When the barilla, (2.), is too cauſtic, the colour of the madder does not fix well, which Mr Gren ſuppoſes is occaſioned by the whole of the oil, with which the cotton was impregnated, being carried off.

9. Mr Gren adviſes to uſe the beſt madder that can be got; chooſing out, in preference, ſuch roots as are neither too large nor woody, about the ſize of gooſe quills; and theſe he only cuts into ſmall morſels. He alledges, that, in ſuch experiments as he had made with ground madder, notwithſtanding every poſſible attention, he had more frequently produced a deep colour,

verging towards brown, than the full clear red ſo much ſought after.

10. I have repeated Mr Grens proceſs *, and moſt of Mr Voglers numerous and intereſting experiments, beſides making ſeveral original experiments of my own deviſing. I ſhall not load the attention by detailing all my experiments, but ſhall only give an account of the moſt remarkable reſults.

11. When a ſolution of alum is mixed with a ſolution of acetite of lead, *ſaccharum ſaturni*, an abundant precipi-

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* Mr Berthollet's own obſervations begin here.—T.

tation takes place of ſulphat of lead. A double exchange of elements take place between the two compound ſalts; the acetous acid quits its combination with the oxyd of lead, and combines with the earthy baſis of the alum, forming acetite of alumine, while, at the ſame time, the ſulphuric acid of the alum quits its connection with its original earthy baſis, and unites itſelf to the oxyd of lead, forming ſulphat of lead. This latter ſalt being difficultly ſoluble in water, falls down in a powdery form, while the former, or the acetic of alumine, remains ſuſpended in the liquor, having an exceſs of acetous acid, as is diſcoverable by the odour of the ſolution.

14. This

12. This ſolution, after having its exceſs of acid ſaturated with a little alkaline ſalt and a little chalk, or carbonat of lime, is uſed as a preparation liquor, by calico printers, for impregnating ſuch cotton cloths as are intended to be ſtamped. For this purpoſe, proper ſtamps, wetted with this preparation, are applied to the cloth, which are afterwards dyed with madder. After this operation, they are alternately ſoaked in bran liquor, and expoſed on a bleachfield, by which the madder is diſcharged from the cloth, excepting upon ſuch parts as were impregnated by the fixing or preparation liquor.

13. The above related employment of acetite of alumine, (11.), in the art of calico printing, (12.), ſhows that it

is well adapted, as a preparation liquor, for fixing the colour of madder upon cotton. In fact, I have experimentally found it greatly preferable for this purpoſe to alum, eſpecially when it has its acid properly ſaturated, in the manner of the calico printers, (12.), already deſcribed. Beſides the ſuperiority of this preparation over a ſolution of alum for fixing the colour, it has another property of great uſe to the calico printers, of not being criſtallizable when conſiderably concentrated; whereas the ſolution of alum would criſtalize in theſe circumſtances, which renders it totally unfit for their purpoſes.

14. It appears that the reagents, or preparations which are employed for fixing colours upon ſtuffs that are af-

terwards to be dyed, enter into a true chemical union with the ſubſtances to which they are applied, or at leaſt become decompoſed during their application, and in the ſubſequent proceſſes, in ſuch a manner that one of their conſtituent elements combines with the ſtuffs. Thus, in the uſe of aluminous ſalts for the above purpoſe, the alumine, or earthy baſis of the alum, quits its acid, and unites to the cotton: Hence the reaſon why acetite of alumine is preferable to alum is, that, in the former ſalt, the baſis has a conſiderably weaker attraction for the acetous acid than it has for the ſulphuric acid in the latter ſalt; and hence the uſe of ſaturating the exceſs of acetous acid, (12.), becauſe it is more eaſily decompoſed than when the exceſs of acid is left unſaturated.

15. When alum is ſaturated with potaſh, ſo as to form a ſlight precipitation, I have found it ſuperior as a preparation to alum in its common ſtate; and I believe for the ſame reaſon that it is then more readily decompoſed. The ſolution of arſenic by means of potaſh, (Sect. iii. 30.), anſwers the purpoſe in a ſimilar manner, and even ſeems rather ſuperior.

16. Galling, or preparation in liquor of gall nuts, renders the colour more fixed, and, at the ſame time, ſomewhat deeper. I have uſed the galling proceſs ſucceſsfully in the manner deſcribed ſome years ago, in the proceſs for the

true Adrianople dye, publiſhed by order of government. The gall nuts muſt not, however, be mixed with the madder in the vat; as it prevents the extraction of the colouring matter of the madder. After having waſhed the cotton in alkaline ley, which renders it more fit for being filled with colour, I have always employed the gall liquor as a firſt preparation.

17. In my own experiments, as in thoſe of Mr Vogler, (Sect. iii.), I have always found mucilaginous and gummy ſubſtances to render the colours more fixed; and that glue anſwered this purpoſe in a ſuperior degree to all the reſt.

18. If a ſolution of glue and of alum be mixed together, and the alumine, or earthy baſis of the alum, be precipitated by means of an alkali, the glue precipitates at the ſame time, being combined with the alumine. Hence the glue appears capable of uniting with the alumine, and both together with the cotton; and by this means the cotton acquires animal properties, which favours its reception of the dye. This obſervation may be of ſingular uſe in various dying proceſſes.

19. A complete deſiccation of the ſtuffs, after each ſtep in the proceſs of dying, is of great utility; probably becauſe the water no longer, by its ſolvent power, or affinity to the preparations, oppoſes their decompoſition,

and the ſubſequent union of one of their elements with the ſtuffs. It ſeems of no conſequence whether this deſiccation be ſlow or haſty, providing it be not done too ſuddenly, eſpecially with ſalts of a criſtallizable nature, ſuch as alum; becauſe, in this caſe, the ſolution runs out, before decompoſition takes place, and criſtallizes on the ſurface. This is the chief reaſon why it is preſcribed to dry the ſtuffs, under preparation, in the ſhade inſtead of the ſun.

20. I have experienced that long macerations and boilings in the preparations were of no avail; it being quite ſufficient that the cotton be thoroughly impregnated with the liquor. We do not even produce more effect

by repeating the aluming two or three times, than by one preparation.

21. If the fulneſs and fixity of colour be the principal objects of attention with the dyer, the following are the ſteps by which, according to my experiments, theſe objects may be beſt obtained. The cotton muſt, in the firſt place, be properly cleaned in an alkaline ley: it is then galled, or dyed in a preparation liquor of gall nuts; dried and rinced: the next ſtep is to impregnate it either with a liquor compoſed of alum and alkaline ſolution of arſenic, or of ſaturated acetite of alumine; dried and rinced: after this it muſt be ſoaked in a ſolution of glue, and again dried and rinced: and, laſt of all, it muſt be dyed while wet, to allow the

dye to act equally over the whole, in a madder vat containing glue. If ſome common ſalt be added in one or other of the previous preparations, the colour is thereby made ſomewhat ſtronger.

22. By this, or a ſimilar proceſs, a very full and ſtanding colour is produced, but of a rather browner ſhade, and leſs lively than the true Turkiſh dyed cotton. The two proceſſes by which I have approached neareſt to the Turkiſh, or Adrianople dye, without uſing oil, is either to employ, as a preparation, the nitrous ſolution of the precipitate obtained from alum by means of potaſh, according to Mr Voglers proceſs; or to add ſome oxyd of

tin * to the madder vat. By this latter proceſs I have produced a red, which might eaſily be miſtaken for Turkiſh. I ſhall give a compariſon of their fixity hereafter.

23. I have repeated Mr Grens proceſs with great ſucceſs, only ſubſtituting gall nuts inſtead of ſumach; but the colour produced, though very nearly reſembling the Turkiſh, was much leſs capable of reſiſting the action of alkaline leys, of ſoap, and of the air.

24. We

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* Mr Berthollet certainly means a ſolution of tin in nitric, or nitro-muriatic acid, as the oxyd, without an acid, is inſoluble in water.—T.

24. We have ſeen in Mr Voglers experiments, (Sect. iii. 21.), that he could not ſucceed when he impregnated the cotton with oil; notwithſtanding of which, it is certain, that, without the uſe of ſome greaſy ſubſtance, it is hitherto impoſſible to produce a colour which ſhall equal the Turkiſh in ſtrength, brilliancy, and fixity. The inteſtinal liquor from ſheep, which, under the name of *ſikion*, is employed in the Adrianople proceſs, ſeems to act in conſequence of the greaſy particles it contains, and by means of ſome matter analogous to ſerum or glue, which is found in all animal ſubſtances.

25. In the St Peterſburgh Journal for 1776, Mr Pallas informs us, that

the Armenians commence the preparation of cotton, in their proceſs for dying Turkiſh red, with greaſe or fiſh oil. It is probable that Mr Vogler omitted to conſider, that the cotton ought only to be cleaned from greaſe, by the alkaline leys, to a certain degree.

26. That the cotton which has been dyed at Adrianople retains ſome ſmall impregnation of oil, is, in ſome degree, confirmed by the following experiment. A ſkain of cotton was ſoaked in ſoap water, gently wrung, and dried; it was then ſteeped in alum liquor ſaturated with potaſh, dried, and dyed with madder. It acquired by this proceſs a full dark madder red; but, after boiling in ſoap water for two minutes,

it became of the true Turkiſh hue, the fixity of which was not examined.

27. If cotton which has been dyed with madder, by any of the foregoing proceſſes, be boiled for ſome minutes in ſoap water, it acquires a roſe colour; and a greaſy matter may be wrung out of it, which has the true Adrianople colour, and will dye white cotton.

28. The quality of madder has great influence on the kind of colour produced by the foregoing proceſſes, as is very juſtly obſerved by Mr Gren. It ſeems indiſpenſibly neceſſary, for the production of true Turkiſh red, that a ſpecies of madder, called *lizari*, be employed, which grows in the Levant.

29. Three portions of cotton were expoſed for a conſiderable time to the action of the air. The firſt was dyed in a madder vat with the addition of a ſolution of tin, and reſiſted the action of the air in a degree ſuperior to the others: The ſecond was dyed in a common madder vat, having been previouſly prepared in the nitric ſolution of alumine; and this acquired a degree of yellowiſh ſhade in conſequence of the air: The third was of the true Adrianople dye; it was more weakened than either of the other two, but without any change of ſhade.

30. When theſe three portions were tried, by boiling in ſoap water, as a teſt, the Adrianople, or true Turkiſh dye, was leaſt altered in colour.

31. The oxygenated muriatic acid diſcharges the true Turkiſh colour more readily than the two others.

32. On the contrary, as is obſerved by Mr Vogler, (Sect. iii. 4.), the Turkiſh reſiſts the teſt of nitric acid more forcibly than the others.

33. From theſe experiments it appears, that we have two ſeparate qualities to be conſidered, with regard to the durability of the colours of cotton that has been dyed with madder. The power of reſiſting againſt the action of the air, and that of ſuſtaining the action of alkalies and of ſoap. The latter cannot be obtained without the uſe of greaſy ſubſtances, or of oil, in ſome of the previous ſteps of the dying pro-

ceſs; while the former depends chiefly upon the quality of the preparation liquors employed, and the number of intermediate deſiccations between the various ſteps of the proceſs. Hence, it ſeems proper to uſe the former * proceſs in dying ſuch ſtuffs as are liable to undergo the action of alkaline leys, or of frequent waſhings with ſoap.

34. Mr Wilſon, in his Eſſay on Light and Colours, makes an obſervation which is worthy of attention. He ſays, that ſuch ſtuffs as have been fabricated with cotton which has not been ſpun by

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* Why might not the advantages ariſing from both proceſſes be combined, by a judicious employment of both kinds of preparation?—T.

by Mr Arkwrights machines, cannot be dyed in the manner of the Adrianople, or Turkiſh proceſs, without having its fillaments too much broken, and rendered rough and wooly, in the numerous operations of the dying proceſs; whereas, ſuch cotton as has been carded and ſpun by the machine, preſerve the paralelliſm of its fibres much better, and admits of being dyed in the ſame manner, without injury to its tiſſue.

35. As we can produce colours equal, if not ſuperior, to the Adrianople dye, in their quality of reſiſting the action of the air, by means of much ſhorter proceſſes than the Turkiſh one; and, as cotton goods are not intended for being frequently ſubmitted to the action

of alkaline leys, and waſhing often with ſoap, it appears better to uſe ſome of the proceſſes deſcribed in the preceding pages of this treatiſe, or others upon ſimilar principles, in preference to the Adrianople proceſs.

36. It is worthy of remark, that, in the foregoing experiments, the action of muriatic acid, (31.), is ſimilar to that of the air, (29.); while the nitric acid, (32.), and ſoap water, (30.), act in a ſimilar manner upon ſuch colours as were expoſed to them; ſo that the oil which is combined with the cotton in the Turkiſh dye, defends it againſt the action of theſe latter teſts, while it has no ſuch effect when expoſed to the action of the air.

37. It appears likewiſe, from my experiments, that the colours dyed by means of madder are rendered more tranſparent, and more brilliant, by the addition of a ſolution of tin. The colouring particles of the dye are more readily, and more abundantly, fixed upon cloth, previouſly prepared in the common manner, by a liquor compoſed of alum and tartar; and the colour is fuller, and more beautiful, when the tin is uſed than when omitted. Notwithſtanding of which, theſe advantages do not appear to exiſt in a ſufficient degree to warrant the uſe of this proceſs.

38. A ſolution of zinc, employed inſtead of tin, produces a beautiful orange colour; a dark brick duſt co-

lour is produced by a ſolution of lead; a ſolution of iron produces no ſenſible effect. An account of the combination of metallic oxyds with the colouring particles of vegetable ſubſtances, may be ſeen in the firſt volume of the Annales de Chymie.

SECT. V.

Abſtract of a MS. Account of a Proceſs for Dying Cotton of the True Turkiſh Red[*].

1. PREPARATION *of barilla waters, or alkaline leys.*

Make a large gimblet hole near the bottom of a deep and narrow tub, ſtanding on two ſticks over a large broad tub; ſtop the gimblet hole lightly with a ſmall ſpigot, and about twenty wheat ſtraws; place a hoop at the bottom of the tub of a ſomewhat ſmaller diameter; upon that lay a ſtratum of ſtraw, ſoaked either with water, or with (No. 3.) barilla water; and over the ſtraw lay about two gallons of well waſhed ſmall pebbles.

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[*] Taken from a very confuſed deſcription of the proceſs, ſaid to be copied from an original by Mr Johnſon, in poſſeſſion of the Glaſgow Chamber of Commerce. It was purchaſed from the tranſcriber, and communicated

Things being prepared in this manner, put into the tub 50 pounds of Alicant, or Spaniſh barilla, and fill the tub with water, allowing it gently to filtrate through the ſpigot hole till 60 gallons have run off, which will be in about

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to me, by an eminent and ingenious dyer in Edinburgh.—T.

about forty hours. This is for the ſtrongeſt, or (No. 1.) barilla water. The firſt time of preparing it upon a freſh ſtratum of ſtraw and pebbles, 60 pounds of barilla ſhould be uſed for the above quantity of water; and in all the after operations of the ſame kind, while the ſtraw remains unchanged, 50 pounds of barilla will ſerve the purpoſe. The weakeſt, or (No. 4.) barilla water, may be uſed with advantage inſtead of common water.

Remove the filtrating tub to another large flat tub, and from the grounds of the firſt filtration, adding more water, draw off 40 gallons of (No. 2.) barilla water.

Remove again the filtrating tub to a third large tub, and with freſh water, ſtill from the ſame grounds, draw off 52 or 54 gallons of (No. 3.) barilla water.

And, laſtly, ſtill from the ſame grounds, with freſh water, draw off 100, 150, or 200 gallons (No. 4.) barilla water; which, in all your ſubſequent operations, is to be uſed inſtead of common water.

Care muſt be taken, eſpecially at the ſetting of a freſh tub with barilla, that if any of the liquor runs milky, it muſt be poured back into the tub, being unfit for uſe; and the grounds muſt be ſtirred well up with an iron ladle before each ſucceſſive filtration.

The ſame ſtraw will ſerve a good many years, taking away the pebbles after the firſt or ſecond ſeries of filtrations, and laying on a little freſh ſtraw, properly moiſtened, above the old every new ſeries.

2. *Preparation of dung liquor.*

Mix four gallons of freſh ſheeps dung, gathered in a dry day, with twenty gallons of water, or of (No. 4.) barilla water, working it well with the hands into a fluid ſtate; let it ſettle for an hour or two, and then run it thro' a fine ſieve.

3. *To prepare* 66 *pounds cotton yarn for the operations.*

Let the bands of every hank be made of good thread, put on wide, and divide the whole into quantities, or little bundles, of a quarter of a pound each. Into each of theſe put a line of two feet long, properly tied, of ſoft, boiled pack thread, in ſuch a manner as to let the bundles hang ten or eleven inches below the dye ſticks. Divide the whole ſo as to form twelve larger bundles, twiſting the above pack threads together; taking care that the hanks in one dying be all of an equal length.

4. *Firſt operation, or boiling the cotton.*

Take four gallons (No. 2.) barilla water in a pail, and pour into it ſlowly, from a heighth, four and a half pounds common galipoli olive oil, mixing them well together with the other hand; or with a ſtick. When properly mixed, put this into a large dying copper; and mix other four and a half pounds of the ſame oil with other four gallons of (No. 2.) barilla water, and add them likewiſe to the copper. Then pour into the copper twenty-four gallons (No. 1.) barilla water; after this twelve gallons of dung liquor; and, laſtly, forty-eight gallons of ſoft water, or of (No. 4.) barilla water.

The fire is now to be lighted under the copper, putting on the lid; and, when the mixture is about ſcalding hot, ſixteen or twenty gallons of the liquor is taken out to make room for the cotton, which is now to be put into the boiler, one bundle at a time, linking the twiſted ſtrings of each ſucceſſive bundle together, ſo as to form a kind of chain, to the laſt link of which a chord muſt be tied, to prevent the ſtrings being loſt during the boiling. The cotton is puſhed under the ſurface of the liquor with a dye ſtick; and, after turning it ſeveral times, ſeven or eight dye ſticks are put in, ſo as to keep the whole down; and, the lid being put on, the liquor is kept boiling as quick as poſſible, ſo as not to run over, for five hours and a half at leaſt, adding gradually the reſerved liquor as the reſt boils away.

When taken out, each diviſion is hung up to cool, with as much liquor as it can contain without dripping; and, when cool, the whole is well wrung, to ſave as much liquor as poſſible for uſe in the after operations.

Such is the firſt operation, which, to ſave the expence of oil, may, in proceſſes after the firſt, be varied as follows: 48 gallons of liquor remaining after the 4th and 8th operations; 24 gallons of (No. 1.) barilla water; 4 gallons of barilla liquor and oil ſaved from the brightening operation; 12 gallons of dung liquor; and 4 gallons of liquor left from a firſt operation in a former proceſs. This is to be uſed exactly in the ſame way we have already directed; and its remains are to be preſerved for the laſt brightening operation.

After the cotton has been completely wrung from either of theſe liquors, it muſt be exceedingly well waſhed in ſoft water, and thoroughly wrung, and then hung up to dry in the open air, if the weather is good, or otherwiſe in a drying houſe, and afterwards completely in a ſtove.

5. *Second operation, or firſt green liquor proceſs.*

Into four gallons of (No. 2.) barilla water, pour ſlowly, from a heighth, $3\frac{1}{2}$ lbs. galipoli oil; when well mixed, put theſe into a taper tub, and add 6 gallons (No. 1.) barilla water, and 4 gallons of dung liquor; mix theſe well together, and ſoak the cotton in it, ſix or eight ſtrings at a time, for two or three minutes; then wring the cotton very thoroughly, ſaving the liquor wrung out for the next operation, and let the cotton be well dried, firſt in the air, and afterwards in the ſtove.

6. *Third operation, or ſecond green liquor proceſs.*

Three pounds and a half galipoli oil are mixed, as before, with 4 gallons (No. 2.) barilla water; to this are added 4 gallons (No. 1.) barilla water, 4 gallons dung liquor, and the remains of the green liquor uſed in the laſt operation; and the cotton is ſoaked, wrung, and dried, as before.

7. *Fourth operation, or third green liquor proceſs.*

This is exactly the ſame as the laſt; only, that the oil is mixed with 2 gallons (No. 2.) barilla water; to which are added 4 gallons (No. 1.) barilla water, 3 gallons dung liquor, and the remains of the former operation.

8. *Fifth operation, or firſt white proceſs.*

Three and a half pounds of oil are mixed, as before, with three and a quarter gallons (No. 2.) barilla water; and, when well mixed, three and a quarter gallons (No. 2.) barilla water, and 4 gallons (No. 1.) barilla water, are added, omitting the dung liquor. The cotton is ſoaked, wrung, and dried, exactly as in the green proceſſes.

9. *Sixth operation, or ſecond white proceſs.*

Three and a half pounds of oil are mixed with 4 gallons (No. 2.) barilla water, as before; then 4 gallons (No. 1.) barilla water, and the remains of the former proceſs, are added; and the cotton is again ſoaked, wrung, and dried, as before.

10. *Seventh operation, or laſt white proceſs.*

The ſame quantity of oil, 5 gallons (No. 2.) barilla water, 4 gallons (No. 1.) barilla water, and the remains of the former proceſs, are mixed, as before directed; and the cotton is again ſoaked, wrung, and dried as before.

The remains from this proceſs are reſerved for uſing in the 14th operation.

11. *Eighth operation, or ſoaking proceſs.*

Warm fifty-four gallons (No. 3.) barilla water, till the hand can juſt be held in the liquor; then put in the cotton, with its ſtrings chained together, as directed in the boiling proceſs; keep it down with dye ſticks; put on the cover of the copper, and let the whole ſoak for ten or twelve hours at leaſt, or for two or three days, if time permits. When taken out, wring it very well, and then waſh two or three times in the river very thoroughly; wring again, and dry it thoroughly as before. The liquor remaining

ing of this proceſs, together with the remains of the green liquor of the fourth proceſs, is to be reſerved for the boiling operation of the next parcel of cotton.

12. *Ninth operation, or firſt galling proceſs.*

About 24 gallons of water are put into a ſmall copper; and, when nearly boiling, 16 lbs. powdered galls are added; or, if of the beſt blue galls, ſomewhat leſs will ſerve. When the liquor is thoroughly boiling, remove the fire; and, when it is cold enough for the hands to bear it, put a paleful at one time into the wringing tub. adding more as it is ſucked up by the cotton. In this liquor, as hot as it can be uſed, waſh the cotton thoroughly; wring it well; dry it firſt in the air, and afterwards in the ſtove. In this proceſs a handful only, or about $1\frac{1}{2}$ lb. of the cotton, is operated upon at one time. The remainder of the liquor is returned into the copper for the next operation.

13. *Tenth operation, or ſecond galling proceſs.*

The gall liquor being again heated upon the drugs, and allowed to ſettle, the cotton is waſhed, wrung, and dried as before. In theſe two laſt proceſſes, the cotton is not to be waſhed in water, but the gall dye is left in to be fixed in the aluming proceſs. The remainder of the liquor is reſerved for after proceſſes of the ſame kind, or for black dyes. A different ſet of drying poles muſt be uſed in this proceſs, as thoſe uſed for the proceſſes with oil would be apt to turn the dye black.

14. *Eleventh proceſs, or firſt aluming.*

Thirty pounds of Roman alum are diſſolved in 16 gallons of water, conſtantly ſtirring the mixture, in a copper. The fire is to be withdrawn when the ſolution is hot enough to allow the hand being held in it; and, when the alum is completely diſſolved, add, by little and little at a time, ſix gallons (No. 1.) barilla water.

In half of this ſolution, the cotton is to be ſoaked, wrung, and dried, and the remaining ſolution carried back to the copper, for uſe in the next proceſs.

15. *Twelfth proceſs, or ſecond aluming.*

The remainder of the alum ſolution being warmed, as before, the cotton is a ſecond time ſoaked, wrung, and dried, firſt in the air, and then in the ſtove. After this, the cotton muſt be extremely well waſhed at the river two or three times, dried thoroughly in the air, and by the ſtove.

16. *Thirteenth operation, or dying.*

Fill a proper ſized dying copper with water, to within ſix inches of the top;

into this put fourteen pounds of ſheeps blood, run through a ſieve, and ſtir them well together; then add twenty-four pounds beſt Smyrna, or twenty-one pounds beſt Cyprus madder; light the fire under the copper; and, when the dye is juſt hot enough to bear the hand, put in the cotton; at firſt only dipping into the liquor, and working it up and down, and backwards and forwards, for near an hour; it is then ſunk entirely below the ſurface, and boiled for forty minutes, or three quarters of an hour *. Being now taken

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* The MS. gives a very minute account of the manner in which it is to be turned, ſoaked, &c. in the dye, for the purpoſe of dying the whole equally; theſe being well underſtood by the practical dyer, are here omitted.

taken out and allowed to drain, it is carried to the river, waſhed, wrung, and dried, firſt in the air, and then in the ſtove.

17. *Fourteenth operation, for fixing the dye.*

In four or five gallons of white liquor, remaining after the ſeventh operation, with the addition of four gallons (No. 1.) barilla water, the cotton is ſoaked thoroughly, then wrung, and dried in the air, and by the ſtove. Or this may be done with the following mixture; five gallons of white liquor remaining from the ſeventh operation, four

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eſpecially as mere deſcription cannot poſſibly form an artiſt.—T.

four gallons of the remaining green liquor from the fourth proceſs, and four gallons of the remainder from the eighth, or ſoaking proceſs.

18. *Fifteenth operation, for brightening the colour.*

Fill a copper half full of ſoft water, to which add twenty-eight or thirty gallons of the remains from the firſt, or boiling proceſs; the copper being of ſuch a ſize as to be thereby filled within five or ſix inches of the top. When near boiling, put in the cotton, having its ſtrings linked together, in a chain, as formerly directed; and, when it is all under the ſurface, lay ſome damp coarſe linen round the edges of the copper; put on the lid, and ſecure it firmly. About half a pound of the cotton is kept ſeparate from the reſt, which is let down into the copper by a ſtring, through a ſmall hole in the lid; which hole muſt likewiſe be cloſe covered by a ſeparate lid.

Every thing being properly diſpoſed, the fire is raiſed, and the copper kept boiling for ſeven, nine, twelve, or fifteen hours, taking out the ſeparate half pound occaſionally, to inſpect its colour. The longer the boiling, the paler the colour. When the colour is brought to the deſired ſhade, take it to the river and waſh it thoroughly; then dry it in the ſhade, and keep it in cloſe bags. The colour turns brighter by keeping.

19. *To heighten the colour ſtill farther.*

For each pound of cotton take two pounds of ſoap, and three gallons of water *, and boil the cotton in this for a full hour, then rince it well in the river, and dry it thoroughly. After this, take one pound of alum, and three gallons of water, for each pound of cotton, and boil in this for an hour; then waſh thoroughly at the river, and dry well in the air.

20. *To ſtiffen the cotton.*

Mix one pound of flour with ſix gallons of water, which will ſize thirty pounds of cotton; ſoak it in this ſtarch milk warm; wring it very well, in the ſame way directed for the green and white operations, and dry it well, as before.

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* This ſeems a much larger quantity of ſoap liquor than is neceſſary.—T.

21. *The French proceſs uſed at Preſte.*

The boiling, green liquor, white liquor, and eighth operation, the ſame as above directed; galling once; aluming once, without barilla; dying the ſame as above; fourteenth operation the ſame; brightening with ſoap and bran.

22. *General obſervations.*

Grey cotton anſwers better than white for this operation. It is of the utmoſt conſequence that the cotton be thoroughly waſhed, and completely dried, as above directed, after each proceſs, before beginning the next operation. It is likewiſe of great moment that all the tubs, drying poles, dye ſticks, wringing pegs, and every thing uſed, be completely cleaned for each operation; or, rather, it were proper to have diſtinct ſets for the different proceſſes. Sheeps blood is the beſt, as bullocks blood is apt to make the colour too dark. The blood will keep ſome days, if ſtirred till cold. Cypreſs madder is the beſt, and Smyrna next in goodneſs; keep the madder in the root, neither too dry nor too damp; and only grind as much at a time as will ſerve for about three weeks.

By the foregoing proceſs, ſixty five pounds of cotton was increaſed to ſeventy-eight, before it was put into the madder vat. Common gallipoli, or coarſe olive oil, is the only kind fit for this proceſs; lintſeed oil turns the colour black.

23. *Eſtimated expence of the foregoing proceſs.*

50 lbs. barilla, at L. 1 : 10 : 0 per cwt. and grinding -	L. 0	14	7
21 lbs. or 3 gallons oil, at 8 d. per lb. - -	0	14	0
24 lbs. ſheeps dung -	0	2	6
16 lbs. gall nuts, at 9 d. per lb. - - -	0	12	0
Carried forward	L. 2	3	1

Brought forward L.	2	3	1
30 lbs. alum, at L. 1 : 14 : 0 per cwt. - -	0	9	4½
107 lbs.* Smyrna madder, at L. 2 : 7 : 6 per cwt.	2	6	9½
14 lbs. ſheeps blood -	0	1	0
Carriage of materials from London, ſay - -	0	12	0
Rent of work-houſe and utenſils - -	0	5	6
Carriage of the goods to dye-houſe, and back	0	2	0
Wages - - -	1	6	0
L.	7	5	9

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* In the dying proceſs, only 24 lbs. of madder are ordered.—T.

Which, for 66 lbs. of cotton, is nearly 2 s. 2½ d. for each pound; or, if the overcharge of madder be deducted, the expence of the whole proceſs amounts only, according to the above account, to 1 s. 8 d. for each pound of cotton.

APPENDIX.

EXPLANATION OF TERMS.

INSTEAD of explaining the chemical terms uſed in Mr Berthollets Eſſay on Madder Dying, in notes, as is done in the Eſſay on the New Method of Bleaching, it is thought better to give an alphabetical liſt of ſuch as require explanation, with the correſpondent terms in the old chemical nomenclature, and a ſhort account of the nature of the ſubſtances.

Acetat—Any ſalt containing acetic acid united with an alkaline, earthy, or metallic baſe.

Acetic acid—Radical vinegar.

Acetite—Any ſalt containing acetous acid united with a baſe.

Acetite of alumine—A neutral ſalt, in which the acetous acid is united with earth of alum.

Acetite of copper—Verdegris. The acetous acid united with oxyd of copper.

Acetous acid—Diſtilled vinegar.

Album grecum—A fanciful antiquated term for the white excrement of dogs which have fed upon bones.

Alumine—Earth of alum; pure argillaceous earth, argil, or arga.

Ammoniac—The volatile alkali in its pure or cauſtic ſtate, called *ſpirit of ſal ammoniac*, prepared with quick lime.

Biſmuth—A ſemi-metal, called by the pewterers *tin-glaſs*.

Carbonat—Any of the alkaline, earthy, or metallic baſes, united with carbonic acid.

Carbonat of magneſia—Mild or aërated

magneſia; magneſia combined with carbonic acid.

Carbonat of potaſh—Mild or aërated vegetable fixed alkali; potaſh or lixa united with carbonic acid.

Carbonat of ſoda—Mild or aërated mineral fixed alkali; ſoda or trona combined with carbonic acid.

Cobalt—A ſemi-metal.

Cobaltum galena—The grey, or blue-grey ore of cobalt.

Gaſtric juice—Properly ſignifies a peculiar liquor ſecreted in the ſtomach of animals, for the purpoſe of digeſtion; but is uſed by Mr Berthollet to denote the digeſted food of animals, as of ſheep, impregnated with the proper ſecreted liquor, and contained in the ſtomach and ſmall guts.

Lixa—Potaſh, or pure vegetable fixed alkali.

*Mangane*ſ*e*—A ſemi-metal.

Muriat—Any neutral ſalt in which the muriatic acid is combined with an alkaline, earthy, or metallic baſe.

Muriat of ammoniac—Sal ammoniac. Amona, or volatile alkali, combined with muriatic acid.

Muriat of alumine—Arga, alumine, or earth of alum, united to muriatic acid.

Muriat of copper—Copper combined with muriatic acid.

Muriat, corroſive, of mercury—Corroſive mercury ſublimate; mercury combined with muriatic acid.

Muriat of ſoda—Common or ſea ſalt; the muriatic acid united with ſoda, trona, or the mineral alkali.

Muriatic acid—Acid of ſalt, or ſpirit of ſea ſalt.

Nitrat—Any ſalt compoſed of nitric acid united with a baſe.

Nitrat of copper—Copper united with nitric acid.

Nitric acid—Acid, or ſpirit of nitre.

Nitric ſolution of lead—Lead diſſolved to ſaturation in nitrous acid.

Nitro-muriat—Any ſalt compoſed of nitro-muriatic acid united with a baſe.

Nitro-muriatic acid—Aqua regia, a compound acid, conſiſting of nitric and muriatic acids mixed together.

Oxyd—A general term, denoting the ſtate of a metal which is combined with oxygen, or baſe of pure air; formerly called *calx*.

Oxyd of lead—Calx of lead.

Oxyd, ſemivitrified, of lead—Litharge.

Oxyd of tin—Calx of tin.

Oxygen—The baſe, or ſolid matter of pure air.

Potaſh—Lixa, or pure vegetable fixed alkali.

Serum—The watery parts of the blood, after the craſſamentum, or coagulable part, has been ſeparated, by ſtirring till cold.

Soda—Fixed mineral alkali in its cauſtic or pure ſtate, otherwiſe called *trona.*

Sulphat—Any neutral ſalt conſiſting of ſulphuric acid, united with an alkaline, earthy, or metallic baſe.

Sulphat of iron—Vitriol of iron, or green vitriol; iron united with ſulphuric acid.

*Sulphat of mangane*ſ*e* — Mangane*ſ*e united with ſulphuric acid.

Sulphat of tin—Tin united with ſulphuric acid.

Sulphat of zinc—White vitriol; zinc united with ſulphuric acid.

Sulphuric acid—Acid of vitriol; or oil of vitriol.

Tartarite—Any ſalt compoſed of tartarous acid united with a baſe.

Tartarite acidulous—Any tartarite in which the acid is in exceſs, but in a certain degree of under-ſaturation, capable of entering into ſeveral chemical compoſitions, as an acid, without being decompoſed.

Tartarite, acidulous, of potaſh—Cream of tartar: Potaſh, or lixa, ſuper-ſaturated with tartarous acid; or tartarous acid under-ſaturated with potaſh.

Zinc—A ſemi-metal, called *ſpelter* by the braziers.

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ADDITION

TO THE

ESSAY ON BLEACHING.

SINCE this edition was printed, the ſixth volume of the Annales de Chymie has come to hand; as it contains ſome additional remarks on the new bleaching proceſs by Mr Berthollet, they are added by the tranſlator, to fulfill his promiſe in the preface, of giving the earlieſt intelligence of every information he may receive that is connected with the ſubject.

1. Mr Welter alledges that it is of great conſequence to finiſh the new bleaching proceſs, by ſpreading the linen yarn, thread, or cloth, for three or four days on a field, watering them frequently; and, laſtly, to waſh them thoroughly in ſoft water. He thinks this indiſpenſibly neceſſary for removing a ſlight yellowiſh tinge, which the goods would otherwiſe retain; but he adds, that this is not neceſſary with cotton goods.

Mr Berthollet obſerves, that other perſons have bleached the ſame goods, to the entire ſatisfaction of the traders, without uſing the above additional proceſs; and that, from repeated experience, he is convinced flaxen goods may be brought to the moſt perfect ſtate of whiteneſs by means of the new bleaching proceſs, without expoſure to the air. He adds, however, that when the goods happen to be compreſſed in particular parts, during the immerſions in the oxygenated liquor, which is very difficultly prevented, theſe are apt to retain a yellowneſs which will ſometimes require repeated oxygenations and alkaline leys to remove. Theſe additional immerſions both add to the expence of the proceſs and tend to weaken the ſtuffs; he therefore recommends Mr Welters plan to be followed in ſuch circumſtances only, as it will remove the yellowneſs with little trouble, delay, or expence, and requires a very ſmall bleaching green.

2. Mr Decroiſille writes to Mr Berthollet, that he has been miſinformed as to the derilection of the new bleaching eſtabliſhment at Rouen, which is, on the contrary, in a very proſperous ſtate. The new manufactory bleaches all kinds of cotton goods, the finer flaxen ſtuffs, and threads and ſtockings nearly at the ſame price with the common bleachers. The white it produces is more perfect than that of the beſt Engliſh bleaching. Cotton yarn, bleached by the new proceſs, takes on the Turkiſh red dye to much greater advantage than when bleached by the ordinary method, and near a third part of the labour and expence of the dying proceſs is ſaved by a judicious employment of the oxygenated liquor, in certain parts of the proceſs, in con-

currence with the other ingredients; leſs oil is neceſſary in the previous ſteps, and a much finer colour is produced.

According to Mr Decroiſille, the diſcovery of the uſe of the oxygenated liquor for bleaching will be of infinite conſequence to the city of Rouen; for, beſides the excellent white which it produces on new goods, many of the merchants find it greatly to their advantage to employ his eſtabliſhment for diſcharging the colours from unſaleable dyed and printed goods; none of theſe colours can withſtand its action, and the goods are rendered as white as if they had never been either dyed or printed, without the ſmalleſt injury to their texture.

3. Mr Decroiſille adds, that in his opinion he has greatly improved Mr Berthollet's proceſs. He uſes very large diſtilling matraſſes, capable of containing ſixty pounds of ſulphuric acid, with a proportional quantity of the other ingredients; has given up the uſe of wood, both in the conſtruction of the troughs in which the goods are ſubmitted to the action of the oxygenated liquor, and of the pneumatic caſk or receiver, in which the water is impregnated with the oxygenated muriatic acid gas; but he does not inform us what theſe are compoſed of, nor the principle on which the receiver is made, which is entirely different from that uſed by Mr Berthollet.

Mr Berthollet remarks, that this ſubſtitution of a ſubſtance on which the oxygenated liquor cannot act, inſtead of wood, for the conſtruction of the receiver and troughs, muſt prove of great importance, as both the loſs of the liquor, which formerly acted on the wooden veſſels, and the expence of repairing and replacing theſe veſſels, when injured, is thereby avoided.

4. In the former publication Mr Berthollet deſires the goods to be plunged into cold water, when taken from the acidulous liquid or ſour; but, from farther experience, he now finds this precaution inſufficient, and recommends the uſe of a weak alkaline ley, moderately warm, in which the goods muſt be ſteeped for a few minutes.

5. He remarks that, before the newly prepared oxygenated liquor is run from the receiver or pneumatic caſk into the troughs for immediate uſe, it is neceſſary to mix it thoroughly by a briſk uſe of the agitator, as otherwiſe the ſtrongeſt impregnated liquor, which lies at the bottom, would run out firſt, and might injure the goods by its too great action.

When the liquor is required as ſtrong as poſſible, this agitation may be diſpenſed with, and a half or two thirds of the liquor, being the loweſt and moſt fully ſaturated, may be firſt run off. This muſt afterwards be reduced to a proper ſtrength by the addition of water, as directed in the Eſſay; and the weaker liquor remaining in the receiver may be uſed in the ſubſequent impregnating proceſs, with the addition of water to fill the receiver.

6. As he underſtands that ſeveral perſons have undertaken the management of the new bleaching proceſs, who have no adequate chemical knowledge, and without paying any attention to the particular qualities of the goods they were to bleach, and that, owing to theſe circumſtances, they either failed of ſucceſs altogether, or the proceſs became too expenſive, ſo as in both caſes to throw unmerited diſcredit on the diſcovery, when the fault was really in themſelves ; he recommends, that, though the new bleaching proceſs be extremely ſimple and eaſy in its application, it ſhould never be at-

tempted without the aſſiſtance of a perſon familiarly converſant in chemical operations, to direct its firſt trials, and to give proper inſtructions for carrying on the different ſteps of the proceſs.

7. He inſiſts very ſtrongly, that a proper diminution of the expence of the new proceſs, or even an equalization of its coſt with that of the common method, except for cottons, and the finer flaxen goods, cannot be expected without the employment of an economical proceſs for extracting the ſoda from the reſidua of diſtillation. Without this, to aſſiſt in defraying the charges, it is in vain to attempt eſtabliſhments for bleaching coarſe linen-goods, unleſs where the celerity of execution, the readineſs of application

in all places, and at all ſeaſons, and the diminution of capital neceſſary for carrying on buſineſs, are ſufficient to counterbalance the exceſs of expence.

It is impoſſible to eſtabliſh any accurate data from which, *a priori*, to aſcertain theſe circumſtances; but he recommends to ſuch as are intereſted to begin by repeated trials on a ſmaller ſcale, by means of which the neceſſary calculations reſpecting the comparative advantages of the two methods may be made. In theſe trials, and conſequent calculation, it is neceſſary not to be deceived by too great hopes of the proceſs proving leſs expenſive, in proportion, on the great ſcale, than in the ſmaller trials; while, on the contrary, the manufacturer ſhould not be diſcouraged by the failure of his firſt eſſays, as, from want of expertneſs, and many other circumſtances, which experience will amend, conſiderable loſs of liquor and of ingredients will occur at firſt, which may afterwards be avoided. He would therefore adviſe to repeat theſe eſſays pretty frequently, both before aſcertaining the comparative advantages of the two methods, and before proceeding to execute the proceſs on a large ſcale, as in this way the data will be more perfect, and the operator, at a ſmall expence, will acquire proper expertneſs for conducting the proceſs.

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